Phase II RFI/RI Work Plan Alluvial

Manual No.

21100-WP-OU 02.1

Volume I - Text & Attachment



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By: F.J. Curran

Date: 7/25/91

91-0104

ENVIRONMENTAL MANAGEMENT

Manual:

21100-WP-OU 02.1

Phase II RFI/RI Work Plan Alluvial (OU 02.1)

Date:

August 19, 1991

Approved by:

OU Manager/

TECHNICAL MEMORANDUM 1

FINAL PHASE II RFI/RI WORK PLAN (Alluvial)

ROCKY FLATS PLANT

903 PAD, MOUND, AND EAST TRENCHES AREAS

(OPERABLE UNIT NO. 2)

VOLUME I (TEXT AND ATTACHMENT)

U.S. DEPARTMENT OF ENERGY Rocky Flats Plant Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

19 August 1991

TECHNICAL MEMORANDUM 1

FINAL PHASE II RCRA FACILITY INVESTIGATION REMEDIAL INVESTIGATION

WORK PLAN (ALLUVIAL)

ROCKY FLATS PLANT 903 PAD, MOUND, AND EAST TRENCHES AREAS (OPERABLE UNIT NO. 2)

ENVIRONMENTAL RESTORATION PROGRAM

U.S. Department of Energy Rocky Flats Office Golden, Colorado

19 July 1991

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Ву	F. J. Curran	<i>,</i> ;	7/6 -
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EXECUTIVE SUMMARY

This document presents the work plan for the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial Investigation (RFI/RI), of the 903 Pad, Mound, and East Trenches Areas (Operable Unit Number 2) at the Rocky Flats Plant. An initial (Phase I) field program was completed during 1987, and a draft RI report was submitted to the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH) on December 31, 1987 (Rockwell International, 1987a). This Phase II RFI/RI Work Plan presents sitespecific plans for further field work to characterize contaminant sources and the extent of soils, surface water. and ground-water contamination. Also included are plans for human health and environmental risk assessments and a RCRA Corrective Measures Study/CERCLA Feasibility Study (CMS/FS). This work plan is based on results presented in the draft RI report as well as subsequent surface water and ground-water sampling and analysis. In order to fully characterize the location, extent, and orientation of bedrock sandstones and subsequently the extent of contamination within these units, a seismic geophysical program was implemented at Operable Unit Number 2 (OU No. 2). A separate Phase II RFI/RI Work Plan (Bedrock) has been prepared and submitted under separate cover presenting results of the ongoing seismic survey and plans for further bedrock ground-water investigations (EG&G, 1991a). The data obtained during the two components of the RFI/RI field work will be combined and presented in a single RFI/RI report. That report will be the basis for the CMS/FS and the baseline risk assessment.

A final Phase II RFI/RI Work Plan for OU No. 2 was submitted to EPA and CDH on 12 April 1990 (EG&G, 1990a). This August 1991 document is Technical Memorandum 1 of the Final Phase II RFI/RI Work Plan (Alluvial) and incorporates agency comments on the 12 April 1990 submittal. Although not required by the Inter-Agency Agreement (IAG), Technical Memorandum 1 was prepared so that final agency comments are reflected in a single document prior to implementation of the Phase II (alluvial) scope of work. This better assures that the RFI/RI and CMS/FS are conducted in accordance with a plan to which all parties are in agreement. It is noted that this plan has also been modified for reasons not associated with specific agencies comments. These changes have been made to "update" the plan with respect to the current understanding of the site, other OU study activities that impact OU No. 2, and regulatory issues. Major changes are as follows:

- Revision of geological characterization based on the on-going seismic reflection study.
- Addition of a concise site conceptual model.
- Elaboration on data quality objectives.
- Discussion of all Rocky Flats Plant treatability study programs.

- Addition of five plume characterization wells between the OU and site boundary because of the recent occurrence of contamination in this location.
- Elimination of surface water station sampling (except seeps) because the activity is covered by OU Nos. 5 and 6 as well as a site-wide surface water characterization program.
- Addition of a more extensive surface soil sampling program to assess the mobility of plutonium in the soil/water environment.
- Addition of a detailed environmental evaluation work plan.
- Elaboration and modification to the discussion of applicable or relevant and appropriate requirements (ARARs).

The 903 Pad, Mound, and East Trenches Areas, located on the east side of the Rocky Flats Plant security area, were selected for investigation because of their suspected relationship to ground-water contamination. Based on existing results, carbon tetrachloride, tetrachloroethene, and trichloroethene are the primary volatile organic contaminants found in the upper hydrostratigraphic unit (HSU) [this includes the alluvium and hydraulically interconnected bedrock sandstone (uppermost sandstone)] ground-water flow system at these areas. Trace elements commonly occurring above background levels in upper HSU ground water include strontium, barium, copper, and nickel, and to a lesser extent chromium, manganese, selenium, lead, zinc, and molybdenum. Also, major cations and anions and total dissolved solids are somewhat elevated above background throughout and downgradient of the 903 Pad, Mound, and East Trenches Areas. Uranium-238 is the predominant radionuclide occurring above background in the upper HSU ground-water flow system, but a few samples indicate plutonium and americium downgradient of the 903 Pad and possibly north of the Mound. An evaporative concentration conceptual model has been advanced that may explain high total dissolved solids, metals, and uranium in ground water at OU No. 2. This model does not alter the borehole and well placement strategy in the Phase II plan, and its veracity will be tested in the background characterization study.

There is considerable interaction between surface water and ground water. As a result, organic contamination is observed in seeps downgradient of the 903 Pad and in the upper reaches of South Walnut Creek at the Mound Area. Also, there are somewhat elevated concentrations of total dissolved solids, major ions, strontium, zinc, and uranium at many of the surface water stations.

Plutonium and americium occur above background in surface soils. Other radionuclides and trace metals occur at low concentrations and are infrequently above background but may also be soil contaminants at the 903 Pad, Mound, and East Trenches Areas. Data suggest plutonium and americium were released to soils in the area via wind dissemination during clean-up efforts at the 903 Drum Storage Site. These radionuclides occur in surface soils throughout the 903 Pad, Mound, and East Trenches Areas and other downwind areas to the southeast.

Plutonium and americium are also observed in two seeps (SW-50 and SW-53) downgradient of the 903 Pad

and in the upper reaches of South Walnut Creek. This may be attributed to the water from the seeps coming

in contact with surface soils exhibiting elevated concentrations of these radionuclides. This hypothesis will be

tested by the Phase II RFI/RI.

This Phase II RFI/RI Work Plan for the 903 Pad, Mound, and East Trenches Areas presents results of the

Phase I RI; defines data quality objectives and data needs based on that investigation; specifies RFI/RI and

CMS/FS tasks; presents a Field Sampling Plan and Environmental Evaluation Work Plan; and provides quality

assurance guidelines and a schedule for conducting the work.

The overall objectives of the Phase II RFI/RI are source characterization and determination of the magnitude

and extent of ground-water and surface water contamination. Boreholes will be drilled into waste sources to

characterize any waste materials remaining in place and to assess the maximum contaminant concentrations

in soils directly beneath the sites. In addition, ground-water monitor wells will be installed adjacent to some

of the boreholes to characterize ground-water quality directly beneath the sites. This plan calls for drilling and

sampling 46 boreholes and the installation of 21 monitor wells. Sixty-four additional alluvial monitoring wells

will be installed to further characterize and monitor ground-water flow and quality in alluvial materials at the

903 Pad, Mound, and East Trenches Areas. An unspecified number of additional bedrock monitoring wells will

be completed in subcropping Arapahoe sandstone where it is encountered. All plume characterization wells

will be installed, developed, and sampled as the first step of the investigation. Source characterization activities

will be performed subsequently. This "step approach" will facilitate early evaluation of the need for an Interim

Measures/Interim Remedial Action to mitigate contaminant migration in ground water of the upper HSU before

issuance of the draft RFI/RI report.

Nineteen surface water stations were established south of the 903 Pad and East Trenches Areas in the Woman

Creek drainage during the 1986 and 1987 investigations, and 12 stations were established north of the Mound

and East Trenches Areas in the South Walnut Creek drainage. One station has been deleted and four have

been added to the sampling program. These 32 stations are being sampled during the monthly site-wide

routine sampling program.

In order to assess the extent of plutonium and americium in surficial soils within Plant boundaries, pedologic

soil samples will be collected from 124 grids over an 800 acre area to the southeast of the 903 Pad. To

delineate the vertical distribution of plutonium and americium, 26 locations have been identified for soil test pit

excavation for soil profile sampling. Additional studies have been planned to assess the mobility of plutonium

in the soil/water environment and are described in Section 5.4, Surficial Soils.

Final Phase II RFI/RI Work Plan (Alluvial) - 903 Pad. Mound, and East Trenches Areas Technical Memorandum 1 Rocky Flats Plant, Golden, Colorado

A baseline risk assessment will be prepared for the 903 Pad, Mound, and East Trenches Areas as part of the Phase II RFI/RI to evaluate the potential threat to the public health and the environment in the absence of remedial action. This risk assessment will provide the basis for determining whether or not remedial action is necessary in the area and serve as the justification for performing remedial actions.

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GLOSSARY OF ACRONYMS

Acronym	Meaning
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
ACL	Alternative Concentration Limit
AEC	United States Atomic Energy Commission
ARARs	Applicable or Relevant and Appropriate Requirements
AWQC	Ambient Water Quality Criteria
BCF	Bioconcentration Factor
CAA	Clean Air Act
CAD	Corrective Action Decision
CCI	Carbon Tetrachloride
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
Cì	Curies
CLP	Contract Laboratory Program
CFR	Code of Federal Regulations
CHCI	Chloroform
cm	centimeter
cm/s	centimeters per second
CMS	Corrective Measures Study
CMS/FS	Corrective Measures Study/Feasibility Study
cpm	counts per minute
CRP	Community Relations Plan
CSU	Colorado State University
CWA	Clean Water Act
DCG	DOE-derived concentration guide
DNAPLs	Dense Nonaqueous-Phase Liquids
dpm	disintegrations per minute
dpm/g	disintegrations per minute per gram
dpm/kg	disintegrations per minute per kilogram
DOE	United States Department of Energy
DOW	Division of Wildlife
DQO	Data Quality Objective
DRCOG	Denver Regional Council of Governments
EE	Environmental Evaluation
EEWP	Environmental Evaluation Work Plan
EIS	Environmental Impact Statement
EMAD	Environmental Monitoring and Assessment Division
EPA	United States Environmental Protection Agency
ER	Environmental Restoration Program
ERDA	Energy Research and Development Administration
FFACO	Federal Facility Agreement and Consent Order
FIDLER	Field Instrument for Detection of Low Energy Radiation

GLOSSARY OF ACRONYMS (Continued)

FR Federal Register
FS Feasibility Study
FSP Field Sampling Plan

ft/ft foot per foot ft/yr foot per year

g gram

g/cm³ grams per cubic centimeter

g/l grams per liter

GFAA Graphite Furnace Absorption Spectroscopy

GRRASP General Radiochemistry and Routine Analytical Services Protocol

GPM Gallons Per Minute GW Ground Water

HASL Health and Safety Laboratory, United States Atomic Energy Commission

HEAST Health Effects Assessment Summary Tables

HSL Hazardous Substance List HSP Health and Safety Plan HSU Hydrostratigraphic Unit

IHSS Individual Hazardous Substance Site

IAG Inter-Agency Agreement — the Federal Facility Agreement & Consent Order (FFACO)

IM/IRA Interim Measures/Interim Remedial Action
IM/IRAP Interim Measures/Interim Remedial Action Plan

IRIS Integrated Risk Information System

KPA kiloPascals kg kilograms

ℓ liter

LOEL Lower Confidence Level
LOEL Lowest Observed Effects Level

m meter Molar

MATC Maximum Allowable Tissue Concentrations

mCi/m² micoCuries per square meter
MCL Maximum Contaminant Level
MCLG Maximum Contaminant Level Goal
MDA Minimum Detectable Activity

mg milligrams

mg/kg milligrams per kilogram mg/l milligrams per liter

ml milliliters
mm millimeters
msl mean sea level

MT&E Measuring and Test Equipment NCP National Contingency Plan

NRDA Natural Resource Damage Assessment

nm nanometers

NPDES National Pollutant Discharge Elimination System OSWER Office of Solid Waste and Emergency Response

OTD Office of Technology Development

OU Operable Unit PA Protected Area

PARCC Precision, Accuracy, Representativeness, Comparability, and Completeness

GLOSSARY OF ACRONYMS (Continued)

PCE Tetrachloroethene

PQL Practical Quantitation Unit pCi/g picoCuries per gram picoCuries per kilogram picoCuries per liter

pCi/m³ picoCuries per cubic meter

QA Quality Assurance

QAA Quality Assurance Addendum
QA/QC Quality Assurance/Quality Control
QAPiP Quality Assurance Project Plan

R/hr Roentgen/per hour

RAAMP Radioactive Ambient Air Monitoring Program
RAID Superfund Risk Assessment Information Directory

RAGS-EEM Risk Assessment Guidance for Superfund-Environmental Evaluation Manual

RAS Routine Analytical Services

RCRA Resource Conservation and Recovery Act of 1976

RfD Reference Dose

RFEDS Rocky Flats Environmental Database System
RFI/RI RCRA Facility Investigation/Remedial Investigation

RFI/RIFS RCRA Facility Investigation/Remedial Investigation Feasibility Study

RFP Rocky Flats Plant
RI Remedial Investigation

RIFS Remedial Investigation/Feasibility Study

ROD Record of Decision

RPD Relative Percent Difference
RPM Revolutions per Minute
SAP Sampling and Analysis Plan
SAS Special Analytical Services

SARA Superfund Amendments and Reauthorization Act of 1986

SDWA Safe Drinking Water Act

SEAM Superfund Exposure Assessment Manual

SED Sediment Sampling Station
SID South Interceptor Ditch

SITE Superfund Innovative Technology Evaluation

SOP Standard Operating Procedures

SPHEM Superfund Public Health Evaluation Manual

SW Surface Water Monitoring Station
SWMU Solid Waste Management Unit

TAL Target Analyte List
TBC To Be Considered
TCE Trichloroethene
TCL Target Compound List

TDR Time Domain Reflectometry
TDS Total Dissolved Solids
TLL Total Long Lived Alpha
TSP Treatability Studies Plan
TVS Table Value Standard
UCL Upper Confidence Level
VOC Volatile Organic Compound

WQCC Colorado Water Quality Control Commission

GLOSSARY OF ACRONYMS (Continued)

 $\begin{array}{lll} \mu \text{Ci} & \text{microcuries} \\ \mu \text{Ci}/\ell & \text{microcuries per liter} \\ \mu \text{g}/\text{kg} & \text{micrograms per kilogram} \\ \mu \text{g}/\ell & \text{micrograms per liter} \\ \mu \text{m} & \text{micrometer} \end{array}$

This document presents the alluvial work plan for the Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial Investigation (RFI/RI) of the 903 Pad, Mound, and East Trenches Areas [Operable Unit Number 2 (OU No. 2)] at the Rocky Flats Plant, Jefferson County, Colorado. It addresses characterization of contaminant sources as well as the nature and extent of contamination in surficial soils, borehole materials, and ground water within the upper hydrostratigraphic unit (HSU). This work plan also presents the tasks that must be completed in the performance of the RCRA Corrective Measure Study/CERCLA Feasibility Study (CMS/FS). A comparable Phase II RFI/RI Work Plan (Bedrock) has been completed which addresses characterization and the nature and extent of contamination in the bedrock and confined water bearing zones beneath the upper (alluvial) HSU (EG&G, 1991a). The data obtained during the "alluvial" and "bedrock" components of the RFI/RI field work will be combined and presented in a single RFI/RI report. This report will be the basis for the baseline risk assessment (included in the RFI/RI report) and the CMS/FS.

This investigation is part of a comprehensive, phased program of site characterization, remedial investigations, feasibility studies, and remedial/corrective actions currently in progress at the Rocky Flats Plant. These investigations are pursuant to the U.S. Department of Energy (DOE) Environmental Restoration (ER) Program [formerly known as the Comprehensive Environmental Assessment and Response Program (CEARP)]; a Compliance Agreement between DOE, the U.S. Environmental Protection Agency (EPA), and the State of Colorado Department of Health (CDH) dated July 31, 1986; and the Federal Facility Agreement and Consent Order (FFACO) [known as the Inter-Agency Agreement (IAG)]. The program developed by DOE, EPA, and CDH in response to the agreements addresses RCRA and CERCLA issues and has been integrated with the ER Program. In accordance with the IAG, the CERCLA terms "Remedial Investigation" and "Feasibility Study" in this document are considered equivalent to the RCRA terms "RCRA Facility Investigation" and "Corrective Measures Study."

1.1 ENVIRONMENTAL RESTORATION PROGRAM

The ER Program is designed to investigate and clean up contaminated sites at DOE facilities. The ER Program is being implemented in five phases. Phase 1 (Installation Assessment) includes preliminary assessments and site inspections to assess potential environmental concerns. Phase 2 (Remedial Investigations) includes planning and implementation of sampling programs to delineate the magnitude and extent of contamination at specific sites, and evaluate potential contaminant migration pathways. Phase 3 (Feasibility Studies) evaluates remedial alternatives and develops remedial action plans to mitigate environmental problems identified as needing correction in Phase 2. Phase 4 (Remedial Design/Remedial Action) includes design and

implementation of site-specific remedial actions selected on the basis of Phase 3 feasibility studies. Phase 5 (Compliance and Verification) implements monitoring and performance assessments of remedial actions, and verifies and documents the adequacy of remedial actions carried out under Phase 4. Phase 1 has already been completed at Rocky Flats Plant (DOE, 1986), and Phases 2, 3, and 4 are currently in progress for OU No. 2.

Phase 2 activities at OU No. 2 include a Phase I RI and subsequent plans for Phase II investigations. An initial (Phase I) field program was completed at the 903 Pad, Mound, and East Trenches Areas in 1987, and a draft Phase I RI report was submitted to EPA and CDH in December 1987 (Rockwell International, 1987a). Based on results of that investigation and regulatory agency comments, planning for a Phase II investigation began in 1988. A draft Phase II RI Sampling Plan was submitted to EPA and CDH in June 1988 (Rockwell International, 1988a), which included plans for further characterization of sources as well as alluvial and bedrock ground-water flow systems. Pursuant to the IAG, a second draft Phase II RI/FS Work Plan was submitted to EPA and CDH in December 1989 (Rockwell International, 1989a) which addressed characterization of sources and the uppermost aquifer (surficial materials and hydraulically connected sandstones). Based on EPA and CDH comments on the draft document, a final Phase II RFI/RI Work Plan for OU No. 2 was submitted to EPA and CDH on 12 April 1990 (EG&G, 1990a). This August 19, 1991, document is Technical Memorandum 1 of the Final Phase II RFI/RI Work Plan (Alluvial) and incorporates agency comments on the 12 April 1990 submittal. Although not required by the IAG, Technical Memorandum 1 was prepared so that final agency comments are reflected in a single document prior to implementation of the Phase II (alluvial) scope of work. This better assures that the RFI/RI and CMS/FS are conducted in accordance with a plan to which all parties are in agreement. It is noted that this plan has also been modified for reasons not associated with specific agencies comments. These changes have been made to "update" the plan with respect to the current understanding of the site, other OU study activities that impact OU No. 2, and regulatory issues. Major changes are as follows:

- Revision of geological characterization based on the on-going seismic reflection study (Section 2.2.1).
- Addition of a concise site conceptual model (Section 2.4).
- Elaboration on data quality objectives (Section 3.0).
- Discussion of all Rocky Flats Plant treatability study programs (Section 4.1.7).
- Addition of five plume characterization wells between the OU and site boundary because of the recent occurrence of contamination in this location (Section 5.2.1.3).
- Elimination of surface water station sampling (except seeps) because the activity is covered by OU Nos. 5 and 6 as well as a site-wide surface water characterization program.

- Addition of a more extensive surface soil sampling program to assess the mobility of plutonium in the soil/water environment (Section 5.4 and Attachment 1.0).
- Addition of a detailed Environmental Evaluation Work Plan (EEWP) (Section 6.0).
- Elaboration and modification to the discussion of applicable or relevant and appropriate requirements (ARARs) (Section 7.0).

Results of the Phase I RI indicate that a depositionally complex bedrock hydrogeologic system exists beneath the 903 Pad, Mound, and East Trenches Areas. A draft Geologic Characterization Report for the Rocky Flats Plant (EG&G, 1990b) has been prepared based on re-evaluation of log data and other geologic information. That report contains a revised working model of the bedrock geology. In order to further characterize the location, extent, and orientation of sandstones, and bedrock facies and stratigraphic relationships, high resolution seismic reflection programs were performed at OU No. 2 (Rockwell International, 1989b and EG&G, 1990c). A separate Phase II RFI/RI Work Plan (Bedrock) (EG&G, 1991a) has been prepared presenting the information provided in the geologic characterization report with the results of the seismic survey to further refine the working model of the bedrock geology.

ER Program Phase 3 and 4 activity to date at OU No. 2 consists of an Interim Measure/Interim Remedial Action Plan (IM/IRAP) for contaminated surface water. A draft IM/IRAP was submitted to EPA and CDH on 12 June 1990 (EG&G, 1990d), and a Draft Final IM/IRAP was submitted to the agencies on 26 September 1990 (EG&G, 1990e). Formal responses to agency comments on the draft IM/IRAP were also submitted with the draft final plan. The Final IM/IRAP, which incorporated public and agency comments on previous drafts, was submitted to CDH and EPA on 8 March 1991 (EG&G, 1991b). Due to public comments, this Final IM/IRAP, unlike the previous drafts, focuses only on South Walnut Creek. A second IM/IRAP for Woman Creek is in preparation.

1.2 WORK PLAN OVERVIEW

This Phase II RFI/RI Work Plan for the 903 Pad, Mound, and East Trenches Areas presents results of the Phase I RI; defines data quality objectives (DQOs) and data needs based on that investigation; specifies Remedial Investigation/Feasibility Studies (RI/FS) tasks; and presents a Field Sampling Plan (FSP). This section (1.0 Introduction) presents site locations and descriptions, and Section 2.0 presents results of the Phase I RI. Included in Section 2.0 are Phase I characterization results for site geology and hydrology as well as the nature and extent of contamination in soils, ground water, surface water, and sediments. Section 3.0 discusses data needs and DQOs for the Phase II RFI/RI investigation. Section 4.0 specifies RI/FS tasks to be performed, and Section 5.0 presents the FSP to meet RI/FS objectives. The EEWP for OU No. 2 is presented in Section 6.0, and the ARARs are presented in Section 7.0. The proposed schedule for conducting the RFI/RIFS is presented in Section 9.0.

The field sampling plan for surficial soil sampling is presented in Attachment 1.0. Responses to EPA and CDH comments on the 12 April 1990 submittal of the OU No. 2 Work Plan have been submitted under separate cover. Appendices A through E contain available data pertaining to OU No. 2 through second quarter 1989 (same data set that was used in the December 1989 submittal). At this time, only a portion of the data have been validated, and these data are identified in the appendices by a qualifier adjacent to each datum. The qualifier "V" means the datum is valid, "A" means the datum is acceptable with qualifications [breach of quality assurance (QA)], and "R" means the datum is rejected. Rejected data either did not conform to the significant aspects of Quality Assurance/Quality Control (QA/QC) procedures identified in the applicable ER Program QA/QC Plan (Rockwell International, 1989c), or there is insufficient documentation to demonstrate conformance with these procedures. These data, at best, can only be considered qualitative measures of the analyte concentrations.

Figure 1-1 depicts the conceptual boundary between the alluvial (upper HSU) and bedrock (lower HSU) components of the RFI/RI. The upper HSU is defined as alluvial deposits and interconnected sandstones, and the lower HSU includes deeper bedrock units. Subcropping sandstones are hydraulically connected with the overlying alluvium and thus are part of the upper HSU. For the purpose of developing work plan scopes, the boundary between the upper and lower HSUs is considered to occur 5 feet below the upper surface of the uppermost claystone. There will be some overlap between the two components of the RFI/RI. However, characterization of the alluvial material and subcropping sandstones will be completed by the alluvial RFI/RI. Overlap will occur in the weathered claystones and where lower sandstones subcrop.

1.3 BACKGROUND AND PHYSICAL SETTING

1.3.1 Background

The Rocky Flats Plant is a government-owned, contractor-operated facility, that is part of the nationwide nuclear weapons production complex. The Plant was operated for the U.S. Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975. At that time, responsibility for the Plant was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by the DOE in 1977. Dow Chemical U.S.A., an operating unit of the Dow Chemical Company, was the prime operating contractor of the facility from 1951 until June 30, 1975. Rockwell International was the prime contractor responsible for operating the Rocky Flats Plant from July 1, 1975, until December 31, 1989. EG&G, Rocky Flats, Inc. became the prime contractor at the Rocky Flats Plant on January 1, 1990, and currently operates the Plant.

1.3.1.1 Plant Operations

The primary mission of the Rocky Flats Plant is to fabricate nuclear weapon components from plutonium, uranium, and other non-radioactive metals (principally beryllium and stainless steel). Parts made at the Plant are shipped elsewhere for assembly. In addition, the Plant reprocesses components after they are removed from obsolete weapons for recovery of plutonium.

Both radioactive and nonradioactive wastes are generated in the production process. Current waste handling practices involve on-site and off-site recycling of hazardous materials, on-site storage of hazardous and radioactive mixed wastes, and off-site disposal of solid radioactive materials at another DOE facility. However, both storage and disposal of hazardous, radioactive, and radioactive mixed wastes occurred on site in the past. Preliminary assessments under the ER Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination.

1.3.1.2 Previous Investigations

Various studies have been conducted at the Rocky Flats facility to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment. The investigations performed prior to 1986 are summarized in Rockwell International (1986a) and include:

- Detailed descriptions of the regional geology (Malde, 1955; Spencer, 1961; Scott, 1960, 1963, 1970, 1972, and 1975; Van Horn, 1972 and 1976; DOE, 1980; Dames and Moore, 1981; and Robson, et al., 1981a and 1981b).
- Several drilling programs beginning in 1960 that resulted in the construction of approximately 60 monitor wells by 1982.
- An investigation of surface and ground-water flow systems by the U.S. Geological Survey (Hurr, 1976).
- Environmental, ecological, and public health studies which culminated in an environmental impact statement (DOE, 1980).
- A summary report on ground-water hydrology using data from 1960 to 1985 (Hydro-Search, Inc., 1985).
- A preliminary electromagnetic survey of the Plant perimeter (Hydro-Search, Inc., 1986).
- A soil gas survey of the Plant perimeter and buffer zone (Tracer Research, Inc., 1986).
- Routine environmental monitoring programs addressing air, surface water, ground water, and soils. These programs are summarized in the annual environmental monitoring reports (Rockwell International, 1975 through 1983a, 1984, 1985, and 1986b). Additional information on routine environmental programs is also presented in post-1986 annual environmental monitoring reports (Rockwell International, 1987b and 1989d, and EG&G, 1990f).

In 1986, two major investigations were completed at the Plant. The first was the ER Program Phase 1 installation assessment (DOE, 1986) which included analyses and identification of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported. A number of sites were identified that could potentially have adverse impacts on the environment. These sites were designated Solid Waste Management Units (SWMUs) by Rockwell International (1987c) and were divided into three categories:

- 1) Hazardous waste management units that will continue to operate and need a RCRA operating permit.
- 2) Hazardous waste management units that will be closed under RCRA interim status.
- 3) Inactive waste management units that will be investigated and cleaned up under Section 3004(u) of RCRA or CERCLA.

The IAG redefines the SWMUs within the second and third categories as Individual Hazardous Substance Sites (IHSSs). The term is used hereinafter; however, no RCRA or CERCLA regulatory distinction in the use of the terms "site," "unit," or "IHSS" is intended in this document.

The second major investigation completed at the Plant in 1986 involved a hydrogeologic and hydrochemical characterization of the entire Plant site. Plans for this study were presented in Rockwell International (1986c and 1986d), and study results were reported in Rockwell International (1986e). Investigation results indicated four areas to be significant contributors to environmental contamination, with each area containing several sites. The areas are the 881 Hillside Area, the 903 Pad Area, the Mound Area, and the East Trenches Area.

Due to their proximity, the 903 Pad, Mound, and East Trenches Areas were grouped together and designated OU No. 2. A Phase I RI of OU No. 2 was completed in December 1987 (Rockwell International, 1987a). Since that time, DOE, in conjunction with EPA and CDH, has been formulating plans for the Phase II RFI/RI as discussed in Section 1.1.

1.3.1.3 Current Investigations and Studies

OU No. 2 is located between three other operable units where current studies are likely to provide data that will support the determination of the nature and extent of contamination at OU No. 2. These operable units are, to the southwest, OU No. 1 (881 Hillside Area), to the south OU No. 5 (Woman Creek), and to the north, OU No. 6 (Walnut Creek). The RFI/RI Phase III Work Plan for OU No. 1 was conditionally approved by the regulatory agencies, and field investigations are scheduled to begin in 1991. The draft RFI/RI Report for OU No. 1 will be submitted in July 1992, well in advance of the OU No. 2 RFI/RI Report (draft report scheduled to be submitted in March 1993). This will permit full utilization of the OU No. 1 findings for the OU No. 2

RFI/RI. The OUs 5 and 6 RFI/RI Work Plans were submitted to the regulatory agencies in April 1991, and the

RFI/RI Reports will be submitted in late 1993. This will permit only partial utilization of data collected for these

OUs.

In addition to these adjacent RFI/RIs, two interim measures/interim remedial actions (IM/IRAs) for

contaminated surface water at OU No. 2 will be conducted during the course of the OU No. 2 RFI/RI. These

IM/IRAs will provide valuable data on the treatability of water contaminated with organics and radionuclides

which will support the detailed evaluation of alternatives for the OU No. 2 CMS/FS. There is also a site-wide

routine sampling program being conducted at Rocky Flats. Surface water stations around the Plant are being

sampled monthly for site-wide characterization of surface waters.

The IAG site-wide activities will augment the RFI/RI and CMS/FS for OU No. 2. In particular, the site-wide

treatability studies will support the detailed evaluation of alternatives for the OU No. 2 CMS/FS (see Section

4.1.7 for additional information regarding treatability studies activities), and the Historical Release Report may

provide additional information on the nature of the wastes disposed at OU No. 2. The draft Historical Release

Report is scheduled to be submitted to the regulatory agencies in January 1992.

Two other Plant-wide studies are being conducted which further affect RFI/RI activities at OU No. 2. First, a

draft Geologic Characterization Report for the Rocky Flats Plant (EG&G, 1990b) was completed in January

1990 based on re-evaluation of log data and other geologic information. This is an ongoing study that

supersedes all previous geologic investigations with the exception of Hurr (1976). The second study of note

is the draft Background Geochemical Characterization Report (EG&G, 1990g). This revised report summarizes

current background data for ground water, surface water, sediments, and geologic materials, and identifies

preliminary statistical boundaries of background variability. It, too, is an ongoing study. Geologic

interpretations are based on information from Hurr (1976) and the Draft Geologic Characterization Report (EG&G, 1990b). These interpretations are subject to change or modification as additional information becomes

available.

1.3.2 Physical Setting

The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of

Denver (Figure 1-2). Other surrounding cities include Boulder, Westminster, and Arvada, which are located

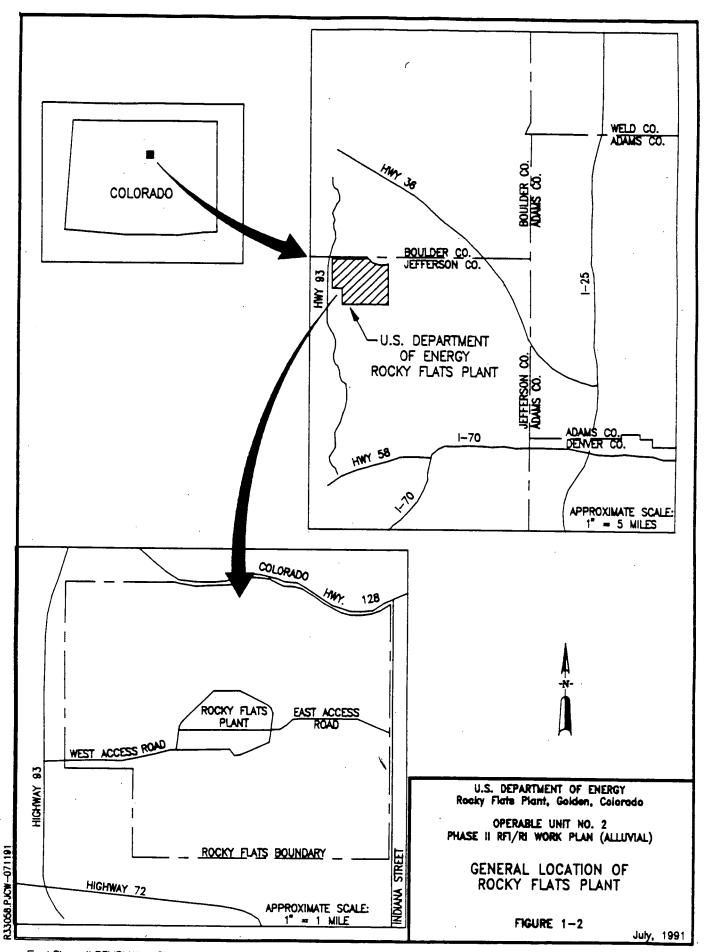
less than 10 miles to the northwest, east, and southeast, respectively. The Plant consists of approximately

6,550 acres of federally owned land in Sections 1 through 4 and 9 through 15 of T2S, R70W, 6th Principal

Meridian. Major buildings are located within the Plant security area of approximately 400 acres. The security

area is surrounded by a buffer zone of approximately 6,150 acres (Figure 1-3).

Final Phase II RFI/RI Work Plan (Alluvial) - 903 Pad, Mound, and East Trenches Areas Rocky Flats Plant, Golden, Colorado Technical Memorandum 1 eg&g\903pad\ou2-ph2\auc sec-1.aug



R33059.PJCW-071191 **EXPLANATION** Colorado Hwy. 128 BOULDER Boulder Co. Jefferson Co./ BROOMFIELD DIVERSION CANAL BUFFER ZONE~ POND C-2 DIVERSION PIPE (8" PVC) DEPARTMENT OF ENERGY Lake (ROCKY FLATS PLANT Great Western Reservo East Access SECURITY AREA West Access Road POND C-2 Ketner Reservoir Operable Unit No. 2 Study Area Mower Reservoir Colorado BUFFER Rocky Flats ZONE Standley Reservoir Ĺoke ROCKY FLATS PLANT PROPERTY LINE SCALE: 1" = 1 MILE Colorado Hwy. 72 Upper Twin 1/2 1 MILE (after: U.S.G.S. Quads.; Louisville, 1979; Golden, 1980; Lafayette, 1979 and Arvada, 1980.) U.S. DEPARTMENT OF ENERGY Leyden Lake Rocky Flats Plant, Golden, Colorado OPERABLE UNIT NO. 2 PHASE II RFI/RI WORK PLAN (ALLUVIAL) TO ROCKY FLATS PLANT COLDEN BOUNDARIES AND BUFFER ZONE Raiston Reservoir FIGURE 1-3 Tucker Lake July, 1991

1.3.2.1 Topography

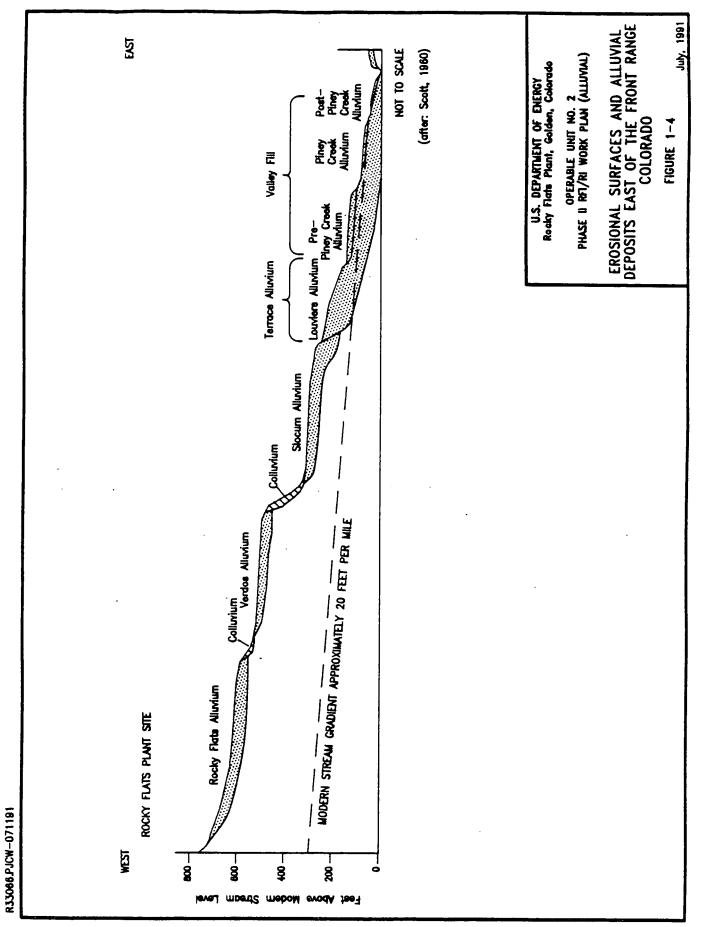
The natural environment of the Plant and vicinity is influenced primarily by its proximity to the Front Range of the Rocky Mountains. The Plant is directly east of the north-south trending Front Range and is located approximately 16 miles east of the Continental Divide. Rocky Flats Plant is located on a broad, eastward sloping plain of coalescing alluvial fans developed along the Front Range at an elevation of approximately 6,000 feet above mean sea level (msl). The fans extend about 5 miles in an eastward direction from their origin at Coal Creek Canyon and terminate on the east at a break in slope to low rolling hills. The operational area at the Plant is located near the eastern edge of the fans on a terrace between stream-cut valleys (North Walnut Creek and Woman Creek).

1.3.2.2 Surface Water Hydrology

Three intermittent streams drain the Rocky Flats Plant with flow generally from west to east. These drainages are Rock Creek, Walnut Creek, and Woman Creek (Figure 1-3). Rock Creek drains the northwestern corner of the Plant and flows northeast through the buffer zone to its off-site confluence with Coal Creek. An east-west trending interfluve separates the Walnut and Woman Creek drainages. North and South Walnut Creeks and an unnamed tributary drain the northern portion of the Plant security area. These three forks of Walnut Creek join in the buffer zone and flow toward Great Western Reservoir which is approximately 1 mile east of the confluence. This flow is, however, routed around Great Western Reservoir by the Broomfield Diversion Canal operated by the City of Broomfield. Woman Creek drains the southern Rocky Flats Plant buffer zone flowing eastward to Standley Reservoir. The South Interceptor Ditch (SID) lies between the Plant and Woman Creek. The SID collects runoff from the southern Plant security area and diverts it to Pond C-2, where it is treated and monitored in accordance with the Plant National Pollutant Discharge Elimination System (NPDES) permit. Treated water from Pond C-2 is then diverted to the Walnut Creek watershed where it is released to the Broomfield Diversion Canal.

1.3.2.3 Regional and Local Hydrogeology

Geologic units beneath the Rocky Flats Plant consist of unconsolidated surficial units [Rocky Flats Alluvium, various terrace alluvia, valley fill alluvium, and colluvium (Figure 1-4)], underlain by Cretaceous bedrock [Arapahoe Formation, Laramie Formation, and Fox Hills Sandstone (Figure 1-5)]. Figure 1-6 presents a generalized stratigraphic section of the Denver Basin bedrock, and Figure 1-7 shows a stratigraphic section for the Rocky Flats Plant. Ground water occurs under unconfined conditions in both surficial and shallow bedrock units. In addition, confined ground-water flow occurs in deeper bedrock sandstones.



High Plains Province July, 1991 Denver & Dawson Formations GENERALIZED EAST—WEST CROSS SECTION FRONT RANGE TO DENVER BASIN OPERABLE UNIT NO. 2 PHASE II RFI/RI WORK PLAN (ALLUMAL) U.S. DEPARTMENT OF ENERGY Rocky Figth Plant, Goldon, Colorado DENVER BASIN FIGURE 1-5 Broadway Laramie Formation - Fox Hills Sanderlans -Valley Fill Alluvium Arapahoe Formation Terroce Allumium Colorado Piedmont Pierre Shale Verdes ROCKY FLATS PLANT (after: Boulder County Planning Commission, 1983 and Scott, 1960) Rocky Flats Raiston Creek Formation Dakota Hogback FRONT RANGE Flatinons Southern Rocky Mountain Province R33081.PJCW-071191 Not to Scale ≥

R33065.PJCW--071191

July, 1991

Rocky Flats Alluvium

The Quaternary Rocky Flats Alluvium is the oldest and topographically highest alluvial deposit at the Rocky

Flats Plant (Scott, 1965). The Rocky Flats Alluvium is a series of coalescing alluvial fans deposited by braided

streams (Hurr, 1976). It consists of a topsoil layer underlain by up to 100 feet of varying amounts of silt, clay,

sand, and gravel. The erosional surface (pediment) on which the alluvium was deposited slopes gently

eastward truncating the Fox Hills Sandstone, the Laramie Formation, and the Arapahoe Formation at the Rocky

Flats Plant.

After deposition of the Rocky Flats Alluvium, eastward flowing streams began dissecting the deposit by

headward erosion and lateral planation. All of the alluvium was removed by erosion in the Woman Creek

drainage south of OU No. 2 and in the South Walnut Creek drainage to the north. The result is a terrace of

Rocky Flats Alluvium extending eastward from the Plant between the two drainages.

Unconfined ground-water flow occurs in the Rocky Flats Alluvium, which is relatively permeable. Recharge to

the alluvium is from precipitation, snowmelt, and water losses from ditches, streams, and ponds that are cut

into the alluvium. General water movement in the Rocky Flats Alluvium is from west to east, and toward the

drainages. Ground-water flow is also controlled by pediment drainages in the top of bedrock. Ground-water

levels in the Rocky Flats Alluvium rise in response to recharge during the spring and decline during the

remainder of the year. Discharge from the alluvium occurs at seeps in the colluvium that covers the contact

between the alluvium and bedrock along the edges of the valleys. Most seeps flow intermittently. The Rocky

Flats Alluvium thins due to erosion east of the Plant boundary and does not directly supply water to wells

located downgradient of Rocky Flats Plant.

Other Alluvial Deposits

Various other alluvial deposits occur topographically below the Rocky Flats Alluvium in the Plant drainages.

Colluvium (slope wash) mantles the valley side slopes between the Rocky Flats Alluvium and the valley

bottoms. In addition, remnants of younger terrace deposits including the Verdos, Slocum, and Louviers Alluvia

occasionally occur along the valley side slopes. Recent valley fill alluvium occurs in the active stream

channels.

Unconfined ground-water flow occurs in these surficial units. Recharge is from precipitation, percolation from

streams during periods of surface water runoff, and by seeps discharging from the Rocky Flats Alluvium.

Discharge is by evapotranspiration and by seepage into other geologic formations and streams. The direction

of ground-water flow is generally downslope through colluvial materials and then along the course of the

stream in valley fill materials. During periods of high surface water flow, water is lost to bank storage in the valley fill alluvium and returns to the stream after the runoff subsides.

Arapahoe Formation

The Arapahoe Formation underlies surficial materials beneath most of the Plant except beneath the western portions of the Plant. From approximately the middle of the west buffer zone and west almost to Highway 93.

the Laramie Formation unconformably underlies the Rocky Flats Alluvium. The Arapahoe Formation is a fluvial deposit composed of overbank and channel deposits. It consists predominantly of claystones and siltstones,

with some silty sandstones beneath the central and eastern portions of the Plant. Total formation thickness varies up to 270 feet (Robson, et. al., 1981a), and the unit is nearly flat lying beneath the Plant (less than 2°

dip) (EG&G, 1990b and 1990c). The sandstone bodies within the claystone are composed of very fine-grained

sand and silt, and their hydraulic conductivity is equivalent to or less than that of the overlying Rocky Flats

Alluvium. Geologic characterization of the Arapahoe Formation beneath Rocky Flats indicates sandstones

occur in stream channel-shaped structures (EG&G, 1990b). The Arapahoe Formation beneath the Plant

contains more clay and silt than typically described for other areas within the Denver Basin.

The Arapahoe Formation is recharged by ground water from overlying surficial deposits and infiltration from

streams. The main recharge areas are under the Rocky Flats Alluvium, although some recharge from the

colluvium and valley fill alluvium likely occurs along the stream valleys. Recharge is greatest during the spring and early summer when rainfall and stream flow are at a maximum and water levels in the Rocky Flats Alluvium

are high. Ground-water movement in the Arapahoe Formation is generally toward the east, although flow within

individual sandstones is controlled locally by the channel geometries. Regionally, ground-water flow in the

Arapahoe Formation is toward the South Platte River in the center of the Denver Basin (Robson, et al., 1981a).

Laramie Formation and Fox Hills Sandstone

The Laramie Formation conformably underlies the Arapahoe Formation and is composed of two units: a thick

upper unit composed predominantly of claystone and a lower unit which contains coal and sandstone. The

upper Laramie Formation is approximately 700 feet thick and is of very low hydraulic conductivity; therefore. the U.S. Geologic Survey (Hurr, 1976) concludes that Plant operations will not impact any units below the

upper claystone unit of the Laramie Formation.

The lower sandstone unit of the Laramie Formation and the underlying Fox Hills Sandstone comprise a

regionally important aquifer in the Denver Basin known as the Laramie-Fox Hills Aquifer (Robson, 1983). Near

the center of the basin, the aquifer thickness ranges from 200 to 300 feet. These units subcrop west of the

Plant and can be seen in clay pits excavated through the Rocky Flats Alluvium. The steeply dipping beds of

these units west of the Plant (approximately 50°) quickly flatten to the east (less than a 2° dip) (EG&G, 1990b and 1990c). Recharge to the aquifer occurs along the rather limited outcrop area exposed to surface water

flow and leakage along the Front Range (Robson, et al., 1981b).

1.3.2.4 Meteorology

The area surrounding the Rocky Flats Plant has a semiarid climate characteristic of much of the central Rocky Mountain region. Approximately 40 percent of the 15-inch annual precipitation falls during the spring season, much of it as wet snow. Thunderstorms (June to August) account for an additional 30 percent of the annual precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, falling from October through May (DOE,

1980).

Special attention has been focused on dispersion meteorology surrounding the Plant due to the remote possibility that significant atmospheric releases might affect the Denver metropolitan area. Studies of air flow and dispersion characteristics (e.g., Hodgin, 1983 and 1984) indicate that drainage flows (winds coming down from the mountains to the west), turn and move toward the north and northeast along the South Platte River

valley and pass to the west and north of Brighton, Colorado (DOE, 1980).

1.3.2.5 Surrounding Land Use and Population Density

The Rocky Flats Plant is located in a rural area. Approximately 50 percent of the area within 10 miles of the Rocky Flats Plant is in Jefferson County. The remainder is located in Boulder County (40 percent) and Adams County (10 percent). According to the 1983 Colorado Land Use Map, 75 percent of this land was unused or was used for agriculture. Since that time, portions of this land have been converted to housing, with

several new housing subdivisions being started within a few miles of the buffer zone.

A recent demographic study shows that approximately 2.2 million people live within 50 miles of the Rocky Flats Plant in 1989 (DOE, 1990a). Approximately 9,100 people lived within 5 miles of the Plant in 1989 (DOE, 1990a). The most populous sector was to the southeast, toward the center of Denver. Recent population estimates, registered by the Denver Regional Council of Governments (DRCOG), for the eight-county Denver metro region have shown distinct patterns of growth between the first and second halves of the 1980s. Between 1980 and 1985, the population of the eight-county region increased by 197,890, a 2.4 percent annual growth rate. Between 1985 and 1989 a population gain of 71,575 was recorded, representing a 1.0 percent annual increase (the national average). The 1989 population showed an increase of 2,225 (or 0.1 percent) from the same date in 1988 (DRCOG, 1989).

There are eight public schools within 6 miles of the Rocky Flats Plant. The nearest educational facility is the Witt Elementary School, which is approximately 2.7 miles east of the Plant buffer zone. The closest hospital is Centennial Peaks Hospital located approximately 7 miles northeast. The closest park and recreational area is the Standley Lake area, which is approximately 5 miles southeast of the Plant. Boating, picnicking, and limited overnight camping are permitted. Several other small parks exist in communities within 10 miles. The closest major park, Golden Gate Canyon State Park, located approximately 15 miles to the southwest, provides 8,400 acres of general camping and outdoor recreation. Other national and state parks are located in the mountains west of the Rocky Flats Plant, but all are more than 15 miles away.

Some of the land adjacent to the Plant is zoned for industrial development. Industrial facilities within 5 miles include the TOSCO laboratory (40-acre site located 2 miles south), the Great Western Inorganics Plant (2 miles south), the Frontier Forest Products yard (2 miles south), the Idealite Lightweight Aggregate Plant (2.4 miles northwest), and the Jefferson County Airport and Industrial Park (990-acre site located 4.8 miles northeast).

Several ranches are located within 10 miles of the Plant, primarily in Jefferson and Boulder Counties. They are operated to produce crops, raise beef cattle, supply milk, and breed and train horses. According to the 1987 Colorado Agricultural Statistics, 20,758 acres of crops were planted in Jefferson County (total land area of approximately 475,000 acres) and 68,760 acres of crops were planted in Boulder County (total land area of 405,760 acres). Crops consisted of winter wheat, corn, barley, dry beans, sugar beets, hay, and oats. Livestock consisted of 5,314 head of cattle, 113 hogs, and 346 sheep in Jefferson County, and 19,578 head of cattle, 2,216 hogs, and 12,133 sheep in Boulder County (Post, 1989).

1.3.2.6 **Ecology**

A variety of vegetation thrives within the Plant boundary. Included are species of flora representative of tall grass prairie, short grass plains, lower montane, and foothill ravine regions. None of these vegetative species are on the endangered species list. It is evident that the vegetative cover along the Front Range of the Rocky Mountains has been radically altered by human activities such as burning, timber cutting, road building, and overgrazing for many years. Since the acquisition of the Rocky Flats Plant property, vegetative recovery has occurred as evidenced by the presence of disturbance-sensitive grass species such as big bluestem (Andropogon gerardii) and sideoats grama (Bouteloua curtipendula). No vegetative stresses attributable to hazardous waste contamination have been identified (DOE, 1980).

The animal life inhabiting the Rocky Flats Plant and its buffer zone consists of species associated with western prairie regions. The most common large mammal is the mule deer (*Odocoileus lemionus*), with an estimated 100 to 125 permanent residents. There are a number of small carnivores, such as the coyote (*Canis latrans*), red fox (*Vulpes fulva*), striped skunk (*Mephitis mephitis*), and long-tailed weasel (*Mustela frenata*). A profusion

of small herbivores consisting of species such as the pocket gopher (Thomomys sp.), white-tailed jackrabbit

(Lepus townsendii), and the meadow vole (Microtus pennsylvanicus) can be found throughout the Plant and

buffer zone (DOE, 1980).

Commonly observed birds include western meadowlarks (Sturnella neglecta), horned larks (Eremophila

alpestris), mourning doves (Zenaidura macroura), and vesper sparrow (Pooecetes gramineus). A variety of

shore birds such as killdeer (Charadrius vociferus), and red-winged black birds (Agelaius phoeniceus) are seen

in areas adjacent to ponds. Mallard ducks (Anas platyrhynochos) as well as other species of (Anas sp.)

frequently nest and rear young on several of the ponds. Common birds of prey in the area include marsh

hawks (Circus cyaneus), red-tailed hawks (Buteo jamaicensis), ferruginous hawks (Buteo regalis), rough-

legged hawks (Buteo lagopus), and great horned owls (Bubo virginianus) (DOE, 1980).

Bull snakes (Pituophis melanoleucus) and rattlesnakes (Crotalus sp.) are the most frequently observed reptiles.

Eastern yellow-bellied racers (Coluber constrictor) have also been seen. The eastern short-horned lizard

(Phrynosoma douglassi brevirostre) has been reported on the site, but these and other lizards are not

commonly observed. The western painted turtle (Chrysemys picta) and the western plains garter snake

(Thamnophis radix) are found in and around many of the ponds (DOE, 1980).

The bald eagle and the black-footed ferret are the two endangered species which were identified as potentially

present at Rocky Flats Plant by the U.S. Fish and Wildlife Service. Bald eagles are occasional visitors to the

area, primarily during migration times. However, eagle sightings are rare and little suitable habitat exists at the

Plant. No bald eagle nests have been found on the Plant site. Prairie dogs provide the food source and

habitat for black-footed ferrets. Since there are no prairie dog towns in or near the 903 Pad, Mound and East

Trenches Areas, ferrets probably do not exist at OU No. 2. Subsequent to a field visit on June 15, 1988, the

U.S. Fish and Wildlife Service has concurred with these findings (Rockwell International, 1988b).

1.4 SITE LOCATIONS AND DESCRIPTIONS

This RFI/RI Work Plan addresses the 903 Pad, Mound, and East Trenches Areas located on the east side of

the Rocky Flats Plant security area. Several sites are included in each area because of their physical proximity-

to each other. Each site was assigned an IHSS reference number by Rockwell International (1987c). Figure

1-7 shows the locations of these areas and the sites within each area. Also shown are buried barrel locations,

determined by visual inspection or magnetometer survey.

Site descriptions presented in the following sections are taken from the Rocky Flats Plant CEARP Phase 1

Report (DOE, 1986) and the RCRA Part B Operating Permit Application (Rockwell International, 1987c). These

descriptions are based on historical records, aerial photography review, and interviews with Plant personnel.

Final Phase II RFI/RI Work Plan (Alluvial) - 903 Pad, Mound, and East Trenches Areas Rocky Flats Plant, Golden, Colorado Technical Memorandum 1 eg&g\903pad\ou2-ph2\aug\sec-1.aug

Further characterization of each site based on other historical reports and Phase I RI results is also included in the following discussions.

1.4.1 903 Pad Area

Five sites are located within the 903 Pad Area (Figure 1-8). These sites are:

- 903 Drum Storage Site (IHSS Ref. No. 112)
- 903 Lip Site (IHSS Ref. No. 155)
- Trench T-2 Site (IHSS Ref. No. 109)
- Reactive Metal Destruction Site (IHSS Ref. No. 140)
- Gas Detoxification Site (IHSS Ref. No. 183)

Descriptions of each site within the 903 Pad Area are provided in the following sections.

1.4.1.1 903 Drum Storage Site (IHSS Ref. No. 112)

The 903 Drum Storage Site is located in the eastern portion of the Plant security zone. This area was used from October 1958 to January 1967 for storage of radioactively contaminated oil drums (Calkins, 1970). Presented below is a description of drums stored at the drum storage site from Calkins (1970).

"Most of the drums transferred to the field were nominal 55-gallon drums, but a significant number were 30-gallon drums. Not all were completely full. Approximately three-fourths of the drums were plutonium-contaminated, while most of the balance contained uranium. Of those containing plutonium, most were lathe coolant consisting of a straight-chain hydrocarbon mineral oil (Shell Vitrea) and carbon tetrachloride in varying proportions. Other liquids were involved, however, including hydraulic oils, vacuum pump oil, trichloroethylene, perchloroethylene, silicone oils, acetone still bottoms, etc. Originally, contents of the drums were indicated on the outside, but these markings were made illegible through weathering and no other good records were kept of the contents. Leakage of the oil was recognized early, and in 1959 or possibly earlier ethanolamine was added to the oil to reduce the corrosion rate of the steel drums."

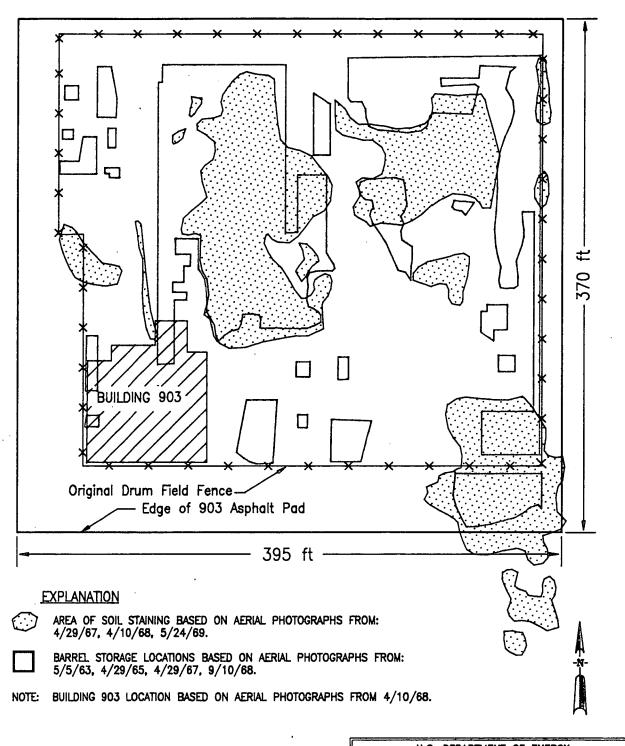
Drum leakage was noted at the 903 Drum Storage Site in 1964 during routine drum handling operations (Dow Chemical, 1971). Corrective action consisted of transferring the contents of leaking drums to new drums and fencing the area to restrict access (Dow Chemical, 1971). Approximately 420 drums leaked to some degree, and of these, an estimated 50 leaked their entire contents (Dow Chemical, 1971). An estimated 5,000 gallons of liquid (Freiberg, 1970) containing 86 grams (g) [5.3 Curies (Ci)] of plutonium leaked into the soil (Dow Chemical, 1971). A heavy rainstorm in 1967 spread contaminants to a ditch south and southeast of the drum storage site (Dow Chemical, 1971); however, the location of the ditch is not provided by this reference. During an investigation conducted by the AEC Health and Safety Laboratory (HASL), it was estimated that

approximately 125 grams of plutonium-239 (Pu-239) was released from the 903 Drum Storage site and redistributed by winds (Krey and Hardy, 1970).

Figure 1-9 outlines drum locations and soil staining at the 903 Drum Storage Site based on a review of historical aerial photography. As seen on this figure, drum storage occurred primarily in the northern and eastern portions of the area. Drums were not stored in the southwest portion where Building 903 was constructed in 1967, and were only briefly stored at the southeast corner. It appears that the drums stored south of the fenced area were placed at this location during clean-up operations, as they appear only in the 1968 aerial photos.

The shipment of drums to the 903 Drum Storage Site ended in January 1967 when drum removal efforts began. Removal of all drums and wastes was completed in June 1968. Presented below is a chronology of the 903 Drum Storage Site clean up as described by Freiberg (1970):

- "From January 23, 1967, through March 10, 1967, uranium oil drums which were in good condition were transferred to Building 774 and processed.
- Building 903 . . . on March 10, 1967, started processing oil drums. This building was designed
 to prefilter the oil prior to transferring plutonium contaminated oil to Building 774 for final
 processing.
- From March 10, 1967, through May 18, 1967, there were a total of 191 drums of plutonium contaminated oil filtered and shipped to Building 774.
- On May 18, 1967, operations at Building 903 were discontinued due to the amount of time this
 process was taking.
- Drum-to-drum transfer in the field began May 18, 1967, and the drums were [SIC] shipped to Building 774 without prior filtration in Building 903.
- From March 17, 1967, through May 10, 1967, in addition to the plutonium transfers, there were 297 drums of uranium contaminated Alk-Tri waste shipped to Building 774 and processed.
- May 10, 1967, through May 28, 1968, a total of 4,826 drums containing 50 gallons of oil each were sent to Building 774 and processed.
- In addition to the oil storage area drums, there were a total of 650 drums from Building 776 current generation sent to Building 774 for processing. A pipeline installed from Building 776 to Building 774 eliminated this additional oil drum generation.
- During the transfer operations, it was noted that at the bottom of all drums a deposit of sludge remained after removal of the oil. This sludge varied in depth from 1/2 inch to 3 inches and averaged approximately 1 inch. By drum counter results the sludge within the empty drums contained a total of 5,152 grams of plutonium. These empty drums were later disposed of by adding Oil Dry and MicroCel to absorb the sludge. The drums containing the plutonium sludge and absorbent were then incased in plastic, placed in boxes, and shipped to the burial grounds." The location of the burial grounds is not provided by Freiberg (1970).



U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

APPROXIMATE LOCATIONS OF DRUM STORAGE-903 PAD DRUM STORAGE SITE

FIGURE 1-9

July, 1991

There were originally a total of 5,237 drums at the drum storage site when clean-up operations began in 1967. After transfer of the contents to new drums, 4,826 drums were transported to Building 774 of which 3,572 drums contained plutonium-contaminated oil. This leaves the contents of 411 drums unaccounted for. The most probable explanation for this discrepancy, according to Freiberg (1970), is a combination of the following factors:

- All of the drums originally sent to the storage site were not completely full.
- Some of the volume was taken up by the sludge which was discarded with the empty barrels.
- Leakage out of the barrels and onto the ground occurred.

Information provided by Freiberg (1970) indicates that an estimated 5,000 gallons of oil leaked from drums onto the ground at the drum storage site. This estimate was based on the memory and knowledge of those involved in site operations (Frieberg, 1970). Based on oil samples taken from barrels, the average plutonium concentration was 4.54 X 10^{-3} grams per liter (q/ℓ) [280 microCuries per liter (μ Ci/ ℓ)]. Thus, approximately 86 g (5.3 Ci) of plutonium were released to soils at the drum storage site (Frieberg, 1970).

In November 1968, site grading began at the 903 Drum Storage Site in preparation for applying an asphalt cap over the area. This work included moving "slightly" contaminated soil from around the fenced area to inside the fenced area (Freiberg, 1970). A total of 33 drums of radioactively contaminated rocks were removed from the area in May 1969, and two courses of clean fill material were placed over the site during the late summer of 1969. The disposal location of the 33 drums was not provided by Freiberg (1970) and is unknown. The asphalt was applied in October 1969, and in February 1970 additional road base course material was applied to soils directly east and south of the asphalt pad due to soil contamination (Freiberg, 1970).

The asphalt containment cover is rectangular and oriented north-south (370 feet) and east-west (395 feet). The pad dips slightly to the northeast at a drop of 1 foot per 100 feet. The asphalt cover is approximately 8 centimeters (cm) (3.2 inches) thick and it is underlain by approximately 15 cm (6 inches) of loose gravel and 8 cm (3.1 inches) of fill dirt (Navratil, et. al, 1979).

1.4.1.2 903 Lip Site (IHSS Ref. No. 155)

During drum removal and clean-up activities associated with the 903 Drum Storage Site, winds redistributed plutonium beyond the pad, primarily to the south and east. An estimated 1 Ci (16.3 g) of plutonium was redistributed beyond the asphalt pad, and of that 1 Ci, approximately 0.56 Ci (9.1 g) is believed to have been

deposited in the 903 Lip Site (Barker, 1982). The most contaminated area was immediately adjacent to the

pad to the south and southeast. Surveys at the time of the drum removal project, and subsequent annual soil

sampling from 1969 to 1972, showed a maximum plutonium concentration of 2,258 picoCuries per gram

(pCi/g) [5,680 disintegrations per minute per gram (dpm/g)] in the top 5 cm (2 inches) of soil at the 903 Lip

Site (Barker, 1982).

Soil clean-up efforts were undertaken in 1978, and 1984 to remove plutonium-contaminated soils from three

different areas within the 903 Lip Site. The 1976 soil removal operation began in June and ended in

September. This cleanup consisted of hand-excavating contaminated soils from an area in the vicinity of the

Reactive Metal Destruction Site until soil contamination levels were below the detection limit of the Field

Instrument for Detection of Low Energy Radiation (FIDLER). The detection limit of the FIDLER is 250 counts

per minute (cpm). The FIDLER "counts" are an instrument-dependent measure of surface activity and cannot

be converted to plutonium concentration in the soil. The excavated area was covered with clean top soil and

reseeded with native grasses. Thirty-five boxes weighing a total of 125,000 pounds were removed and shipped

off site for disposal following the 1976 cleanup (Barker, 1982). The off site disposal location was not provided

Recent radiological surveys have been conducted to further assess radioactive by Barker (1982).

contamination. These include an aerial gamma survey conducted in July 1989 (EG&G, 1990h).

The 1976 soil removal technique hand-excavation was inefficient considering the large amount of contaminated

soils requiring removal at the 903 Lip Site. In June 1978, a second soil removal project began north of the

1976 removal site using a front-end loader alone or in conjunction with a bull dozer. All soil that exceeded

2,000 cpm, as determined by a FIDLER survey, was removed. Cleaned areas were resurveyed and soil

removal continued until background readings (approximately 250 cpm by a FIDLER survey) were obtained.

Topsoil was then applied to the excavated area, and the site was revegetated with native grasses. During the

1978 soil removal, 1,448 boxes weighing approximately 4.7 million pounds were removed and shipped off site

(Barker, 1982). The off-site disposal location was not provided by Barker (1982).

Approximately 0.5 Ci (8.2 g) of plutonium were removed from the 903 Lip Site during the first two soil removal

projects. This quantity is based on an average soil plutonium concentration of 545 pCi/g (1,200 dpm/g) and

a soil density of 1 gram per cubic centimeter (g/cm³) (Barker, 1982).

A third soil clean up was performed along the eastern edge of the 903 Lip Site in 1984. A total of 214 tri-wall

pallets of contaminated soil were removed from the area; however, the soil disposal location was not provided

by Setlock (1984). The excavated area was backfilled with clean topsoil (Setlock, 1984).

1.4.1.3 Trench T-2 Site (IHSS Ref. No. 109)

Trench T-2 is located south of the 903 Drum Storage Site and west of the Reactive Metal Destruction Site. This

trench was used prior to 1968 for the disposal of sanitary sewage sludge and flattened drums contaminated

with uranium and plutonium. This trench is believed to have measured approximately 15 feet wide by 200 feet

long by 5 feet deep (Rockwell International, 1987c). Barrels were noted in the western end of Trench T-2

during 1987 investigations (Figure 1-8).

1.4.1.4 Reactive Metal Destruction Site (IHSS Ref. No. 140)

The Reactive Metal Destruction Site is located on the hillside south of the 903 Drum Storage Site. This site was

used during the 1950s and 1960s primarily for the destruction of lithium (Li) metal (DOE, 1986). Approximately

400 to 500 pounds of metallic lithium were destroyed on the ground surface in this area and the residues.

primarily nontoxic lithium carbonate, buried (Illsley, 1978). Smaller unknown quantities of sodium (Na), calcium

(Ca), and magnesium (Mg), solvents, and unknown liquids were also destroyed at this location (Illsley, 1978).

Historical references do not indicate the method by which constituents were destroyed at the site.

Based on review of historical aerial photography, the Reactive Metal Destruction Site was used from 1968 to

1971. Barrels were noted in the southwestern corner of IHSS 140 during 1987 investigations (Figure 1-8).

1.4.1.5 Gas Detoxification Site (IHSS Ref. No. 183)

Building 952, located south of the 903 Drum Storage Site, was used to detoxify various gases from lecture

bottles between June 1982 and August 1983. The lecture bottles held approximately 1 liter of compressed gas

each. The gases consisted of various types of nitrogen oxides, chlorine, hydrogen sulfide, sulfur tetrafluoride,

methane, hydrogen fluoride, and ammonia which were used in Plant research and development work. Gas

detoxification was accomplished by using various commercial neutralization processes available at the time.

After neutralization, glassware used in the process was triple-rinsed, crushed, and deposited in the present

landfill. The neutralized gases released to the environment during detoxification would no longer be detectable

(Rockwell International, 1987c).

1.4.2 Mound Area

The Mound Area is composed of four sites (Figure 1-8). These are:

Mound Site (IHSS Ref. No. 113)

Trench T-1 Site (IHSS Ref. No. 108)

- Oil Burn Pit No. 2 Site (IHSS Ref. No. 153)
- Pallet Burn Site (IHSS Ref. No. 154)

These sites are described individually below.

1.4.2.1 Mound Site (IHSS Ref. No. 113)

The Mound Site, located north of Central Avenue in the eastern Plant security area, was used between April 1954 and September 1958 for drum disposal. Approximately 1,405 drums containing primarily depleted uranium (U) and beryllium (Be) contaminated lathe coolant (a mixture of about 70 percent hydraulic oil and 30 percent carbon tetrachloride) were placed at the Mound Site (Rockwell International, 1987c). [Records do not indicate that the barrels were actually buried (Calkins, 1970).] It is likely that some of the coolant also contained enriched uranium and plutonium (Rockwell International, 1987c). Some drums also contained Perclene (Smith, 1975). Perclene was a brand name of tetrachloroethane (PCE) (Sax and Lewis, 1987). Some of the drummed wastes placed in the Mound Site were in solid form (Rockwell International, 1987c).

Cleanup of the Mound Site was accomplished in May 1970, and the materials removed were packaged and shipped to an off-site DOE facility for disposal. Listed below is an inventory of the 1,405 drums removed from the Mound Site in 1970 (Dow Chemical, 1971):

No. of Drums	Contents
903	30-gallon drums of depleted uranium solid waste.
21	30-gallon drums of depleted uranium oil waste.
12	30-gallon drums of plutonium contaminated oil waste. "The plutonium content was so low that it was measurable only by the most sensitive laboratory techniques."
102	55-gallon drums of depleted uranium solid waste.
282	55-gallon drums of depleted uranium oil waste.
<u>85</u>	55-gallon drums of enriched uranium oil waste.
1,405	TOTAL DRUMS

Subsequent surficial soil sampling in the vicinity of the excavated Mound Site indicated 0.8 to 112.5 dpm/g (0.4 to 51 pCi/g) activity. This radioactive contamination is thought to have come from the 903 Drum Storage Site via wind dispersion rather than from the Mound Site, as it was limited to the surface (Rockwell International, 1987c).

1.4.2.2 <u>Trench T-1 Site (IHSS Ref. No. 108)</u>

The trench was used from 1954 until 1962 and contains approximately 125 drums filled with approximately 25,000 kilograms (kg) (55,115 pounds) of depleted uranium chips (Dow Chemical, 1971) and some plutonium chips coated with small amount of lathe coolant (hydraulic oil and carbon tetrachloride) (Rockwell International, 1987c). The estimated dimensions of Trench T-1 are 15 feet wide by 200 feet long by 5 feet deep (Rockwell International, 1987c). Trench T-1 was covered with approximately 2 feet of soil, and the corners were marked (Rockwell International, 1987c). Figure 1-8 illustrates the location of Trench T-1 and the location of barrels determined by visual inspection or magnetometer survey during the Phase I RI.

Weed cutting activities in October and November 1968 unearthed two drums inadequately covered with fill material. Both drums were sampled and analyzed for total plutonium and uranium content before they were disposed off site (Illsley, 1983). The off-site disposal location was not provided by Illsley (1983). One of the drums was sampled and contained an oil/water mixture with 55 picoCuries per liter (pCi/ ℓ) of plutonium and 2.3 x 10⁵ pCi/ ℓ of uranium. The other drum contained an oily sludge with 4.6 pCi/g of plutonium and 1.2 x 10⁶ pCi/g uranium (Illsley, 1983).

1.4.2.3 Oil Burn Pit No. 2 Site (IHSS Ref. No. 153)

Oil Burn Pit No. 2 is actually two parallel trenches that were used in 1957 and from 1961 to 1965 to burn approximately 1,082 drums of oil containing uranium (Rockwell International, 1987c). In March and April of 1957, the contents of an estimated 169 uranium-contaminated waste oil drums were burned. No further burning took place until 1961. Frequent burning of waste oil took place from June 1961 to May 1965. The contents of approximately 914 drums were burned during this time. The drums used for the oil burning operations were generally reused; however, 300 empty drums were discarded by flattening and burying them in the burning pits (Dow Chemical, 1971). The uranium concentrations of the burned waste oil are unknown. The residues from the burning operations and the flattened drums were covered with backfill. In 1978, the area was excavated to a depth of approximately 5 feet, and 239 boxes (56 cubic feet per box) of contaminated soil were removed and shipped off site to an authorized DOE disposal site (Illsley, 1983). The specific off-site disposal location was not provided by Illsley (1983).

1.4.2.4 Pallet Burn Site (IHSS Ref. No. 154)

An area southwest of Oil Burn Pit No. 2 was reportedly used to destroy wooden pallets in 1965. The types of hazardous substances or radionuclides that may have been spilled on these pallets is unknown. This site was cleaned up and reclaimed in the 1970s (DOE, 1986). Two locations for the Pallet Burn site are shown on Figure 1-8. The westernmost location was reported by Owen and Steward (1973). However, based on review

of historical aerial photographs, there was no disturbance at this western location. The eastern location was identified from 1963 and 1965 aerial photography of the area.

1.4.3 East Trenches Area

The East Trenches Area consists of nine burial trenches and two spray irrigation sites. These sites are:

- Trench T-3 (IHSS Ref. No. 110)
- Trench T-4 (IHSS Ref. No. 111.1)
- Trench T-5 (IHSS Ref. No. 111.2)
- Trench T-6 (IHSS Ref. No. 111.3)
- Trench T-7 (IHSS Ref. No. 111.4)
- Trench T-8 (IHSS Ref. No. 111.5)
- Trench T-9 (IHSS Ref. No. 111.6)
- Trench T-10 (IHSS Ref. No. 111.7)
- Trench T-11 (IHSS Ref. No. 111.8)
- East Spray Irrigation Sites (IHSS Ref. Nos. 216.2 and 216.3)

Trenches T-3, T-4, T-10, and T-11 are located north of the east access road, and Trenches T-5 through T-9 are south of the east access road. The wastes in these trenches have not been disturbed since their burial. The spray irrigation areas are located east of Trenches T-5 through T-9 (Figure 1-8).

1.4.3.1 Trenches T-3 through T-11 (IHSS Ref. Nos. 110 and 111.1-111.8)

These trenches, as well as Trench T-2, were used from 1954 to 1968 for disposal of approximately 125,000 kilograms (kg) of sanitary sewage sludge contaminated with uranium and plutonium, and approximately 300 flattened empty drums contaminated with uranium (Illsley, 1983). Radiation content of the sewage sludge ranged from 8.4 x 10³ disintegrations per minute per kilogram (dpm/kg) (382 pCi/g) to 7.9 X 10⁶ dpm/kg (3,590 pCi/g) (Owen and Steward, 1973). "Earlier pits involve mostly uranium with an increasing plutonium fraction in later pits" (Owen and Steward, 1973). Total alpha radioactivity in Trenches T-2 to T-8 is estimated to be 100 to 150 millicuries (0.1 to 0.15 Ci) (Dow Chemical, 1971). Trenches T-4 and T-11 also contain some plutonium- and uranium-contaminated asphalt planking from the solar evaporation ponds (Illsley, 1983). The locations of Trenches T-3 through T-11 as well as the location of the barrels, as determined by visual inspection and/or magnetometer survey, are shown in Figure 1-8.

According to Illsley (1983), samples were collected from Trenches T-9, T-10, and T-11, and the results were as follows:

"Samples from T-11 contained plutonium in the range from 4.5 to 50 pCi/g and uranium-238 in the range between 0.9 and 158 pCi/g. Trench T-10 was found to contain uranium in the range between 40 and 126 pCi/g and Pu-239 in the range from 0.18 to 14 pCi/g. . . . Plutonium concentrations in collected samples varied from 0.40 to 68 pCi/g and uranium was found in the range between 2.4 and 450 pCi/g in Trench T-9."

The sampling dates and collection methods of these samples are unknown.

1.4.3.2 East Spray Irrigation Sites (IHSS Ref. Nos. 216.2 and 216.3)

IHSS numbers 216.2 and 216.3 were used for spray irrigation of sewage treatment plant effluent. These areas have been designated as IHSSs because effluent containing low concentrations of chromium (Cr) was inadvertently sprayed in the area in February and March 1989. The chromium entered the sanitary sewage treatment plant on February 23, 1989, subsequent to a spill of chromic acid in Building 444 (Rockwell International, 1989e).

2.1 PHASE I REMEDIAL INVESTIGATION

The Phase I RI consisted of the following field activities:

- Electromagnetic, resistivity, and magnetometer geophysical surveys.
- A soil gas survey.
- Soil sample collection from 33 boreholes (Figure 2-1 and Table 2-1).
- Completion of 10 alluvial and 14 bedrock monitoring wells (Figure 2-1).
- Ground-water sampling of new and previously existing wells.
- Slug testing of 13 wells.
- Packer testing of cored bedrock wells.
- Collection of 22 surface water and seep samples.
- Air monitoring for total long-lived alpha, plutonium, and volatile organics during field activities.

In addition to the Phase I investigation at the 903 Pad, Mound, and East Trenches Areas, several monitor wells were installed in these areas as part of a Plant-wide hydrogeologic investigation in 1986 (Rockwell International, 1986e and Table 2-1). Surface water, soil, and air samples have also been collected at these areas as part of various investigations. Section 2.2 presents results of the Phase I RI and a brief characterization of each pathway at the 903 Pad, Mound, and East Trenches Areas. The nature and extent of contamination associated with these pathways is discussed in Section 2.3, and Section 2.4 presents the site conceptual model.

2.2 SITE PHYSICAL CHARACTERISTICS

A site-specific conceptual model of the 903 Pad, Mound, and East Trenches Areas has been developed based on the Phase I RI results as well as previous and subsequent investigations. This model describes contaminant sources and pathways through which contaminant transport may occur from these areas.

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Table 2-1

903 PAD, MOUND, AND EAST TRENCHES AREAS MONITORING WELL DATA

Well . Number	Geologic Strata of Completion	Ground Surface Elev.(ft.)	Top of Casing Elev.(ft.)	Depth to Top of Screen	Depth to Bottom of Screen	Total Depth (ft.)	Depth to Bedrock (ft.)	Bedrock Elevation	Northing Coordinate (ft.)-RFP	Easting Coordinate (ft.)-RFP	State Northing (ft.)	State Easting (ft.)
3386	Orf	5949.28	5950.70	2.99	7.34	7.34	7.00	5942.28	36960.93	21896.47	749962.6590	2085000.2370
3986	Qrf	5904.91	5906.61	5.00	31.50	31.50	30.50	5874.41	38288.72	27591.82	751290.6447	2090695.5130
4186	Qrf	5940.03	5941.83	3.90	44.70	44.70	44.40	5895.63	36611.43	25437.08	749613.2570	2088540.8520
4286	Qrf	5954.34	5956.43	6.12	29.70	29.70	28.60	5925.74	36565.80	24007.88	749567.5710	2087111.6510
4386	Qrf	5970.39	5972.49	3.99	16.75	16.75	16.50	5953.89	36415.05	22761.70	749416.7604	2085865.4760
1087	Orf	5981.96	5983.53	3.50	12.00	12.00	11.00	5970.96	35959.99	22180.04	748947.0158	2085289.2754
1587	arf	5970.89	5972.99	5.80	22.06	22.53	22.00	5948.89	36020.14	23139.88	749010.3218	2086248.6590
1787	Qrf	5967.56	5969.53	3.50	22.00	25.75	25.00	5942.56	36424.92	23200.70	749415.1940	2086308.1281
1987	Qrf	5967.98	5969.84	3.50	11.65	11.89	11.40	5956.58	36633.42	23064.85	749623.1990	2086171.6264
2487	Qrf	5957.79	5959.66	3.50	13.60	13.85	13.40	5944.39	36759.05	23640.05	749750.6926	2086746.2613
2687	Orf	5954.06	5955.97	4.00	13.45	13.70	13.20	5940.86	36261.48	24381.98	749255.6958	2087489.6385
2787	Qrf	5947.52	5949.73	3.50	43.00	43.25	42.75	5904.77	36442.01	24944.62	749438.0421	2088051.5380
3287	Qrf	5946.12	5948.03	36.00	46.55	46.80	46.30	5899.82	36513.70	25256.21	749510.7405	2088362.8092
3387	Qrf	5945.27	5947.15	15.00	20.00	20.25	19.75	5925.52	36859.07	24815.13	749854.5591	2087920.7058
3587	Q rf	5949.36	5951.42	3.50	9.35	9.60	9.10	5940.26	36981.20	24162.59	749974.5030	2087267.9351
6386	Qc	5900.40	5902.04	3.80	15.25	15.50	14.80	5885.60	35155.84	22641.51	748144.5996	2085753.2740
6786	Qc .	5796.26	5797.73	2.50	14.75	14.75	14.00	5782.26	35706.56	27253.77	748710.4048	2090362.5100-
2987	Qc	5812.42	5814.40	3.50	20.30	20.50	19.80	5792.62	35094.87	24249.82	748088.9555	2087361.3703
4487	Qc	5949.53	5951.26	1.50	3.50	3.70	3.20	5946.33	35317.96	22323.69	748305.6314	2085435.0051
3586	Qvf	5909.20	5911.54		11.60	11.60	10.30	5898.90	37176.97	23114.38	750178.7010	2086218.1420
3686	Qvf	5881.94	5883.78	3.50	6.49	6.50	5.50	5876.44	37395.41	23715.31	750397.1536	2086819.1070
3786	Qvf	5792.02	5794.15	3.29	8.55	8.55	7.75	5784.27	38561.44	25758.47	751563.0018	2088862.4820
6486	Qvf	5834.48	5836.46	3.41	9.00	9.00	8.80	5825.68	34683.82	22497.26	747685.5186	2085601.1100
6586	Qvf	5782.75	5784.40	2.50	8.00	8.00	7.10	5775.65	34886.65	24389.54	747888.4362	2087493.3790
6686	Qvf	5685.12	5686.73	2.50	6.50	6.50	5.80	5679.32	33638.66	28151.55	746640.6086	2091255.4530
2187	Ovf	5927.58	5929.36	3.23	10.40	10.56	10.40	5917.18	36980.21	22693.84	749968.6664	2085799.5648

Table 2-1 (Continued)

903 PAD, MOUND, AND EAST TRENCHES AREAS MONITORING WELL DATA

Well Number	Geologic Strata of Completion	Ground Surface Elev.(ft.)	Top of Casing Elev.(ft.)	Depth to Top of Screen	Depth to Bottom of Screen	Total Depth (ft.)	Depth to Bedrock (ft.)	Bedrock Elevation	Northing Coordinate (ft.)-RFP	Easting Coordinate (ft.)-RFP	State Northing (ft.)	State Easting (ft.)
		,										
0171	Kacl	5950.00	5950.83		29.17	30.05			35823.90	23205.50		
0271	Kacl	5936.20	5936.79		28.64	29.23			35528.12	22831.33		
0174	Kaci	5968.00	5968.80		24.16	24.96			36643.80	23069.00		
0374	Kacl	5950.20	5951.31		23.98	25.04			36944.90	23884.50		
6286	Kass	5897.54	5898.75	25.22	35.19	35.19	22.00	5875.54	35154.34	22613.19	748156.0499	2085717.0180
0987BR	Kass	5980.22	5981.72	14.50	32.15	32.40	12.70	5967.52	36080.84	22239.33	749068.0299	2085348.1453
1187BR	Kass	5913.57	5915.36	15.20	20.25	20.50	5.20	5908.37	35419.39	22989.24	748409.2366	2086100.0436
1287BR	Kass	5934.74	5936.49	4.92	10.00	10.25	4.00	5930.74	35590.92	22956.17	748580.6049	2086066.4205
1487BR	Kass	5855.00	5856.73	19.00	24.05	24.30	5.20	5849.80	35236.67	23504.68	748228.2626	2086615.9564
2387BR	Kass	5972.34	5974.49	17.19	37.61	37.85	15.25	5957.09	36415.15	22802.78	749404.1201	2085910.3415
2587BR	Kass	5958.91	5960.96	17.50	43.45	43.70	16.50	5942.41	36727.08	23641.38	749718.7298	2086747.6965
36878R	Kass	5949.04	5951.12	19.80	63.35	63.59	7.50	5941.54	36985.79	24189.80	749979.1830	2087295.1168
3486	Kass	5910.44	5912.78	44.24	56.25	56.25	16.10	5894.34	37171.41	23088.39	750173.1389	2086192.1520
4086	Kass	5941.23	5942.21	87.98	111.50	111.50	45.00	5896.23	36612.84	25398.09	749614.6648	2088501.8570
1687BR	Kass	5969.06	5970.98	100.00	125.00	125.24	21.90	5947.16	36139.59	23140.49	749129.7454	2086248.8779
1887BR	Kass	5967.38	5969.45	127.00	133.45	133.70	24.60	5942.78	36413.74	23231.24	749404.1222	2086338.6941
2087BR	Kass	5968.10	5970.10	107.26	116.11	116.36	11.80	5956.30	36644.48	23048.42	749634.1973	2086155.1645
2287BR	Kass	5930.70	5932.49	81.41	88.46	88.70	12.80	5917.90	36934.99	22715.72	749923.5377	2085821.5930
28878R	Kass	5947.17	5950.03	187.37	197.37	197.70	43.50	5903.67	36442.31	24983.42	749438.4716	2088090.3222
30878R	Kass	5811.87	5813.80	85.79	94.35	94.35	16.00	5795.87	35095.15	24312.43	748089.4398	2087423.9554
3187BR	Kass	5945.02	5947.56	110.66	129.41	129.64	45.00	5900.02	36502.97	25201.86	749499.8322	2088308.5132
34878R	Kass	5945.21	5947.22	97.29	104.24	104.49	20.00	5925.21	36840.38	24825.73	749835.9078	2087931.3614
4587BR	Kass	5949.42	5951.00	89.50	101.05	101.30	4.00	5945.42	35325.47	22340.05	748313.1987	2085451.3360

2.2.1 Geology

2.2.1.1 Surficial Geology

Surficial materials at the 903 Pad, Mound, and East Trenches Areas consist of the Rocky Flats Alluvium, colluvium, and valley fill alluvium unconformably overlying bedrock (Figure 2-2). In addition, there are a few isolated exposures of bedrock. The area is situated on a pediment covered with Rocky Flats Alluvium which extends eastward from the Plant. The Rocky Flats Alluvium consists of a poorly to moderately sorted, poorly stratified deposit of clay, silt, sand, gravel, and cobbles. A portion of the 903 Pad Area extends south of the pediment toward the SID. Colluvium is present on the hillside south of the 903 Pad and East Trenches Areas, and on the hillside north of the Mound and East Trenches Areas. Valley fill alluvium is present in the drainage of Woman Creek south of the 903 Pad and East Trenches Areas and in the South Walnut Creek drainage north of the Mound Area.

Buried paleodrainages and ridges eroded into the Arapahoe Formation bedrock surface are present at the base of the Rocky Flats Alluvium (Plate 2). A relatively small paleogully is present, starting near the southeast corner of the Mound Area and extending southeast, where it is truncated by the hillside. A larger paleogully starts south of the east end of the East Trenches and trends northeast, traversing the central portion of the East Trenches. A paleoridge is present on the north side of this paleogully, starting in the Mound Area and trending east-northeast across the northwest portion of the East Trenches Area. A topographic high in the bedrock surface occurs on the south side of the larger paleogully just south of the central portion of the East Trenches Area.

2.2.1.2 Bedrock Geology

Significant work has been conducted recently to further characterize bedrock at Rocky Flats. A draft Geologic Characterization Report for the Rocky Flats Plant (EG&G, 1990b) was prepared based on a comprehensive literature search, reprocessing and describing previously obtained core samples, reprocessing previously obtained seismic data, and collecting and analyzing selected samples for grain size analyses. The geologic characterization is an ongoing program that will incorporate all geologic information Plant-wide for continued refinement of the working geologic model. In addition to these efforts, high-resolution seismic reflection profiling was conducted in the OU No. 2 area (EG&G, 1990c). These two studies were conducted concurrently, and the description of bedrock geology presented in this work plan utilizes the results of both.

The Cretaceous-age Arapahoe Formation underlies surficial materials at the 903 Pad, Mound, and East Trenches Areas. The high-resolution seismic reflection program indicated that the Arapahoe Formation dips at less than 2° to the east. The Arapahoe Formation, which is approximately 250 feet thick in the vicinity of the Plant (EG&G, 1990b), consists of fluvial claystones with interbedded sandstones, siltstones, and occasional lignite deposits. Contacts between these lithologies vary from gradational and sharp.

The Arapahoe Formation is the product of a fluvial depositional environment that included meandering streams that flowed east-southeast from the Front Range Uplift. Fining-upward graded sandstone sequences within the formation are representative of both laterally accreted point bar deposits and floodplain splay deposits. Laterally accreted point bar deposits occur by the slow migration of fluvial channels, and splay deposits are formed by breaching of channel banks during floods. Overbank flood deposits consist of very fine sand and mud deposited near the stream channel or on the stream flood plain. Channel fill deposits are formed in abandoned channels by a reduction in stream discharge or by cutoff of a meander (Blatt, et al., 1980).

Based on previous investigations and the ongoing geologic characterization being conducted by EG&G, bedrock in the 903 Pad, Mound and East Trenches Areas is predominantly claystone (EG&G, 1990a). However, six channel sandstone intervals have been preliminarily identified beneath the Rocky Flats Plant. These are general stratigraphic intervals, each of which contains sandstones only at some locations. They have been sequentially numbered according to increasing depth. Thus, Arapahoe Sandstone No. 1 is the uppermost sandstone, which subcrops in many areas. Arapahoe Sandstone No. 6 is present at or near the base of the Arapahoe Formation.

Generally, the Arapahoe Sandstones that occur within 30 to 40 feet of the base of the alluvium are oxidized and are pale orange, yellowish-gray, and dark yellowish-orange. The sandstones that are not in the weathered zone are light gray and olive-gray. Most of the sandstones are very fine- to medium-grained, poorly-to moderately-sorted, subangular to subrounded, silty, clayey, and quartzitic with trough and planar cross-stratification. The claystones and silty claystones are light to medium olive-gray, occasionally olive-black with some dark yellowish-orange claystones in the weathered intervals near the base of the alluvium. The yellowish-orange and yellowish-brown color is the result of the iron oxide staining.

The draft Geologic Characterization Report (EG&G, 1990b) included mapping the estimated areal extent of Arapahoe Sandstone Nos. 1, 3, and 4. The lateral extent of channel deposits in each of these lithologic intervals was estimated based on previous borehole formation. Figure 2-3 shows the estimated lateral extent and thickness isopachs of the Arapahoe Sandstone No. 1 and the estimated lateral extents of the Arapahoe Sandstone Nos. 3 and 4. Sandstone was also found in the Nos. 2 and 5 intervals in several boreholes in the OU No. 2 area. However, there was not sufficient information to estimate the lateral extent of sandstones within these intervals.

Significant areas of the Arapahoe Sandstone No. 1 are known to subcrop beneath the Rocky Flats Alluvium in the 903 Pad, Mound, and East Trenches Areas. It is believed that nearly the entire area shown as the Arapahoe Sandstone No. 1 channel subcrops beneath the Rocky Flats Alluvium. As a result of the significant areal extent of subcropping Arapahoe Sandstone No. 1, and since significant contamination has been found in this uppermost sandstone interval, all of the Arapahoe Sandstone No. 1 is included in the upper HSU. The conceptual boundary between the alluvial and bedrock components of the RFI/RI is located beneath the Arapahoe Sandstone No. 1 as shown in Figure 1-1.

High-resolution seismic reflection profiling (EG&G, 1990c; Rockwell International, 1989f) was conducted to help refine the working model of the bedrock geology, particularly in the OU No. 2 area. There are some differences between the draft Geologic Characterization Report and the high-resolution seismic reflection profiling report in the estimated thickness and areal extent of the Arapahoe Sandstone No. 1. Since the Arapahoe Sandstone No. 1 is considered to be within the upper HSU, further characterization of it and resolution of differences between the Geologic Characterization Report and high-resolution seismic profiling, results will be part of the alluvial RFI/RI activities.

2.2.2 Ground-Water Hydrology

Unconfined ground-water flow occurs in surficial materials and subcropping sandstones. In addition, subcropping claystone may be saturated in some locations, particularly where weathered and fractured. Confined ground-water flow occurs in lower sandstone units. The majority of wells that have been installed in weathered claystone throughout the Plant are unsaturated.

2.2.2.1 Ground-Water Flow System in Upper Hydrostratigraphic Unit

Recharge/Discharge Conditions

Ground water is present in the Rocky Flats Alluvium, colluvium, valley fill alluvium, and subcropping sandstones under unconfined conditions. Recharge to the upper HSU occurs as infiltration of incident precipitation and as seepage from ditches and creeks. In addition, retention ponds along South Walnut Creek and Woman Creek probably recharge the valley fill alluvium.

The shallow ground-water flow system is quite dynamic, with large water level changes occurring in response to precipitation events and stream and ditch flow. Alluvial water levels are highest during the spring and early summer months of May and June. Water levels generally decline during late summer and fall, at which time some wells go dry. The shallow ground-water flow system supports ephemeral flow in the creeks.

Alluvial ground water discharges to seeps, surface water drainages, colluvium, and subcropping Arapahoe sandstone at the 903 Pad, Mound, and East Trenches Areas. Seeps occur along the edge of the pediment margin (at the alluvium/bedrock contact) and on the hillside slopes. Seeps on the hillsides may be due to thinning of colluvial materials. Ground water in valley fill materials discharges to Woman or South Walnut Creeks.

Ground-Water Flow Directions

Ground-water flow in the unconfined system is generally from west to east. Figure 2-4 presents the potentiometric surface for the upper HSU, measured in April 1988, and represents the most extensive area of saturation for surficial materials and subcropping sandstones which exhibit unconfined conditions. Ground-water flow within the Rocky Flats Alluvium is east-northeast in the area, generally following topography. Ground-water flow directions in the subcropping sandstones are probably influenced by the geometry of the sandstone channels (Figure 2-3). Ground water flowing toward the pediment edges emerges as seeps at the contact between the alluvium/subcropping sandstones and claystone bedrock (contact seeps) is consumed by evapotranspiration, or flows through colluvial materials following topography toward the valley fill alluvium. Once ground water reaches the valley fill alluvium, it either flows down-valley in the alluvium, is consumed by evapotranspiration, or discharges to the creek. During the driest periods of the year, evapotranspiration consumes so much water that there is no flow in either the colluvium or the valley fill alluvium. Wells completed in these areas are dry during some portion of the year.

Ground-Water Flow Rates

Hydraulic conductivity values were developed for surficial materials from drawdown-recovery tests performed on 1986 wells during the initial site characterization (Rockwell International, 1986e) and from slug tests performed on select 1986 and 1987 wells during the 1987 Phase I RI (Rockwell International, 1987a). For the Rocky Flats Alluvium, hydraulic conductivities for all tests ranged from 4 x 10⁻⁵ centimeters per second (cm/s) at well 39-86 to 5 x 10⁻² cm/s at well 42-86. The geometric mean hydraulic conductivity for all tests was 4 x 10⁻⁴ cm/s. Based on an average horizontal gradient of 0.02 feet/foot (ft/ft) at the 903 Pad, Mound, and East Trenches Areas, an assumed effective porosity of 0.1, and a mean hydraulic conductivity of 4 x 10⁻⁴ cm/s (Rockwell International, 1987a) the average ground-water velocity in the Rocky Flats Alluvium is 82 feet per year (ft/yr). Based on the ranges of hydraulic conductivity values, ground-water flow velocity ranges from approximately 8 ft/yr to 10,350 ft/yr.

The geometric mean hydraulic conductivity based on drawdown-recovery tests for the Woman Creek valley fill alluvium is 7 x 10⁻⁴ cm/s, and the range is from 5 x 10⁻⁵ cm/s at well 68-86 to 3 x 10⁻³ cm/s at well 65-86.

No slug tests were performed on wells completed in Woman Creek valley fill. Using an average horizontal gradient of 0.02 ft/ft, an assumed effective porosity of 0.1, and a mean hydraulic conductivity of 7 x 10⁻⁴ cm/s, the average ground-water velocity in Woman Creek valley fill is 145 ft/yr (Rockwell International, 1987a). Ground-water flow velocity ranges from 10 to 621 ft/yr based on the range of hydraulic conductivity values.

South Walnut Creek valley fill is less conductive than that along Woman Creek based on lithologic descriptions and hydraulic conductivity tests of well 35-86. A drawdown-recovery test and a slug test have been performed in well 35-86. The hydraulic conductivity of South Walnut Creek Alluvium, calculated from the drawdown-recovery test, was 9 x 10⁻⁵ cm/s. Results of the slug test indicated a hydraulic conductivity of 1 x 10⁻⁴ cm/s. Using the mean conductivity of 9.5 x 10⁻⁵ cm/s, an effective porosity of 0.1, and an average gradient of 0.02 ft/ft, the average flow velocity in South Walnut Creek valley fill is 20 ft/yr (Rockwell International, 1987a).

The average ground-water flow velocities calculated for various surficial materials assume the materials are fully saturated year-round. However, as discussed above, portions of the Rocky Flats Alluvium, colluvium, and valley fill alluviums are not saturated during the entire year. Based on water level data from the area, alluvial wells are dry approximately three months during the year (generally August through October). Thus, ground-water flow may occur only nine months of the year. This results in reduced average ground-water movement in all alluvial materials (approximately 62 ft/yr in Rocky Flats Alluvium, 110 ft/yr in Woman Creek valley fill alluvium, and 15 ft/yr in South Walnut Creek valley fill alluvium).

2.2.2.2 Confined Ground-Water Flow Systems

The greatest potential for ground-water flow in the Arapahoe Formation occurs in the sandstones contained within the claystones. Ground-water recharge to sandstones occurs as infiltration from alluvial ground water where sandstones subcrop beneath the alluvium, and to a very minor extent by leakage from claystones overlying the sandstones.

Following Robson, et al. (1981a) flow within individual sandstones is assumed to be from west to east, but the geometry of the ground-water flow path in the bedrock is not fully understood at this time due to its dependence upon the continuity of the sandstones and their hydraulic interconnection. Also, there is not sufficient information to estimate ground-water flow rates in the lower sandstones at this time. Evaluation of the lateral extent and degree of interconnection of the sandstone units is a primary goal of an ongoing program of profiling the Arapahoe Formation through additional drilling and high resolution seismic reflection studies. This information will be used in conjunction with site hydrologic data to better characterize flow paths in individual sandstones during the Phase II RFI/RI bedrock investigation.

2.2.3 Surface Water Hydrology

2.2.3.1 South Walnut Creek

The headwaters of South Walnut Creek were filled during construction of Plant facilities, and the area is now drained by a series of culverts. The drainage from the Central Avenue area between the 903 Pad and Mound Areas is diverted into a large corrugated metal pipe that discharges into South Walnut Creek beneath a perimeter access road embankment outside of the Protected Area (PA). A second culvert is a large concrete culvert that diverts storm flows from the area east of Building 991 within the PA to South Walnut Creek. This concrete culvert also discharges beneath the perimeter access road and into the South Walnut Creek drainage.

A third culvert diverts flows from the western part of the PA to a point downstream of the two culverts described above. The third culvert terminates near the sewage plant discharge channel in South Walnut Creek. The combined flows, typically less than 10 gallons per minute (gpm) based on flow data from the first three quarters of 1989, then enter the South Walnut Creek retention pond system. Below the retention ponds, South Walnut Creek joins North Walnut Creek and an unnamed tributary within the buffer zone before flowing into Great Western Reservoir located approximately 1 mile east of this confluence.

The South Walnut Creek retention pond system consists of five ponds (B-1, B-2, B-3, B-4, and B-5) that retain surface water runoff and Plant discharges for monitoring and evaluation before downstream release of these waters. All flow downstream of the most downstream pond (Pond B-5) originates from Pond B-5 and is treated and monitored for quality in accordance with the Plant's NPDES permit (discharge point 006). Ponds B-1 and B-2 are reserved for spill control, surface water runoff, or treated sanitary waste of questionable quality, and Pond B-3 is a holding pond for sanitary sewage treatment plant effluent. Pond B-3 is used as a holding pond for sanitary sewage treatment plant effluent. The historical discharge of Pond B-3 was a spray irrigation system located in the vicinity of the East Trenches. This practice has been terminated, however, and the current Pond B-3 discharge is send to Pond B-4. Ponds B-4 and B-5 receive surface water runoff from the central portion of the Plant and occasional discharges from Pond B-3. The surface water runoff received by Pond B-4 is collected by the Central Avenue Ditch and upper reaches of South Walnut Creek (including storm runoff diverted via the two large-diameter culverts). The discharge of Pond B-5 is currently released to retention Pond A-4, located in the North Walnut Creek drainage.

2.2.3.2 Woman Creek

Woman Creek is located south of the Plant with headwaters in largely undisturbed Rocky Flats Alluvium. Runoff from the southern part of the Plant is collected in the SID located due north of the creek and delivered to Pond C-2. Pond C-1 (upstream of C-2) receives stream flow from Woman Creek. The Woman Creek

drainage is located in OU No. 5, which is just south of OU No. 2. The discharge from Pond C-1 is diverted around Pond C-2 into the Woman Creek channel downstream. Water in Pond C-2 is treated and monitored in accordance with the Plant NPDES permit. Treated water from Pond C-2 is then diverted to the Walnut Creek watershed where it is released to the Broomfield Diversion Canal.

Flow in Woman Creek and the SID is intermittent, appearing and disappearing along various reaches. During the 1986 initial site characterization, measurable flow occurred at less than one-half of the 10 stations located along Woman Creek and the SID (Rockwell International, 1986e). All recorded flows were less than 10 gpm. During the 1986 and 1987 investigations, there was no surface flow in Woman Creek downstream of Pond C-2. The intermittent surface water flow observed for Woman Creek and the SID is indicative of frequent interaction with the shallow ground-water system.

2.2.4 Surficial Soils

Surficial soils of OU No. 2 are predominantly moderately deep to deep, well-drained clay loams of moderate to low permeability. The area is drained by Woman Creek, and soils along the flood plain and low terraces have formed in stratified loamy alluvium. The higher, gently sloping soils are formed from Rocky Flats Alluvium, where gravels and cobbles are common. The hillsides in the area are formed from cobbly, gravelly, and loamy alluvium (mixed sources) or claystone. Runoff is generally rapid and erosion hazard can be severe on the steeper slopes. Numerous soil series occur in the area; however, all belong in the Arguistoll great group with the exception of some entisolls in the drainages (Figure 2-5 and Table 2-2). Arguistolls are generally characterized as well-drained soils with mollic (dark) epipedons, argillic "B" horizons, and calcic "C" horizons. They exist in ustic moisture regimes (limited moisture, but adequate for plant growth during growing season). The two predominant subgroups are Torrertic and Aridic, with the Torrertic Arguistolls having more pronounced shrinking and swelling capability (U.S. Department of Agriculture, 1980).

2.3 NATURE AND EXTENT OF CONTAMINATION

2.3.1 Background Characterization

In order to facilitate the interpretation of chemical results in non-background areas, a background characterization program has been implemented to define the spatial and temporal variability of naturally occurring constituents. A plan was completed in January 1989 (Rockwell International, 1989g), field work was conducted, and a draft Background Geochemical Characterization Report was prepared and submitted to the regulatory agencies in December 1989 (Rockwell International, 1989h). The report was recently finalized for submittal in December 1990 (EG&G, 1990g). The document summarizes the background data for ground water, surface water, sediments, and geologic materials, and identifies preliminary statistical boundaries of

TABLE 2-2
SOIL TYPES EAST OF THE 903 PAD

Series Family		Phase	Min-Max Slope (%)	Infiltration Rate	Soil Type*
Denver	Torrertic Arguistolls	clay loam	5-9	slow	27
Denver-Kutch	Torrertic Arguistolls	clay loam	5-9	slow	29
Denver-Kutch-Midway	Torrertic Arguistolls	clay loam	9-25	slow	31
Eng l ewood	Torrertic Arguistolls	clay loam	2-5	slow	42
Flatirons	Aridic Paleustols	sandy loam	0-3	slow	45
Haverson	Ustic Torrifluvents	loam	0-3	moderate	60
Leyden-Primen-Standley	Aridic Arguistolls	cobbly clay loam	15-50	slow	80
Midway	Ustic Torriorthents	clay loam	9-30	slow	98
Nederland	Aridic Arguistolls	sandy loam	15-50 · .	moderate	100
Nunn	Aridic Arguistolls	clay loam	0-2	slow	102
Nunn	Aridic Arguistolls	clay loam	2-5	slow	103
Standley-Nunn	Aridic Arguistolls	gravelly clay loam	0-5	slow	149
₩illowman-Leyden	Aridic Arguistolls	clay loam	9-30	moderate	174

^{*} Soil Type number corresponds to soil type exhibited in Figure 2-6.

Source: U.S. Department of Agriculture, 1980

background variability. Spatial variations in the chemistry of geologic materials and water were addressed by placing sample locations throughout background areas at the Plant. The goal of evaluating temporal variations in water chemistry has not yet been achieved because at least 2 years of quarterly data are needed. Revision of the background report will continue as additional background data are collected.

The boundaries of background variability were quantified through the calculation of tolerance intervals assuming a normal distribution. Assumptions and statistical analyses of the background tolerance intervals are presented in Rockwell International (1989h). The upper limit of the tolerance interval or the maximum detected value for each parameter analyzed in background ground-water, surface water, sediment, and geologic samples are provided in Tables 2-3 through 2-6, respectively. Maximum detected values are provided where there were insufficient data to calculate tolerance intervals. This condition resulted from there being an insufficient number of samples, or where there was an insufficient number of detectable concentrations for a given analyte. Background samples were initially not analyzed for EPA Contract Laboratory Program (CLP) Target Compound List (TCL) organics, because the background areas are outside of potentially contaminated areas. However, as of first quarter 1990, ground-water and surface water samples are being collected in background areas for volatile organic analysis.

To assess the presence of inorganic contamination at the 903 Pad, Mound, and East Trenches Areas, site-specific chemical data are compared to the background tolerance intervals or the maximum detected value if a tolerance interval could not be calculated. A constituent concentration that is greater than the upper limit of the one-sided 95 percent tolerance interval at the 95 percent confidence level will be considered to preliminarily represent contamination. Although not statistically significant, a site-specific chemical concentration above the maximum detected background value is considered a very preliminary indication of contamination in the following assessment.

Radionuclides are analyzed by counting subatomic particle emissions, which is a random function. Since radioactive disintegration is a statistical process and therefore has a probability distribution, results are reported as a measured value with an associated two standard deviation propagated error term indicated in parentheses immediately following the measured value. Computation of tolerance intervals for radionuclides did not account for the error term associated with each datum. Techniques are under investigation to account for propagation of error resulting from computation. For the purposes of this plan, the boundaries of the background variability for radionuclides will be the tolerance intervals as computed in the draft Background Geochemical Characterization Report. Site radionuclide concentrations where the error term is larger than the measured value are below the minimum detectable activity (MDA) and are considered not statistically different from background. Measured values which exceed their associated counting errors are considered above background if they are greater than the upper limit of the calculated tolerance interval. Because this comparison does not account for the propagated error associated with the upper limit of the background

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TABLE 2-3

BACKGROUND GROUND-WATER (ROUND 1) TOLERANCE INTERVAL UPPER LIMITS OR MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (11 Samples)	Colluvium (2 Samples)	Valley Fill Alluvium (8 Samples)	Weathered Claystone (4 Samples)	Weathered Sandstone (2 Samples)	Unweathered Sandstone (7 Samples)
Dissolved Metals							
Aluminum	mg/t	ND	ND	ND	ND	ND	0.327*
Antimony	mg/L	ND	ND	ND	ND	ND	ND
Arsenic [°]	mg/t	ND	ND	ND	ND	ND	0.0186*
Barium	mg/Ł	ND	ND	ND	ND	ND	ND
Beryllium ·	mg/t	ND	ND	ND	ND	ND	ND
Cadmium	mg/€	ND	ND	ND	ND	ND	ND
Calcium	mg/Ł	85	76.8*	138	73.4*		64.6
Cesium	mg/£	ND	ND	ND	ND	ND	ND
Chromium	mg/£	ND	ND	ND	ND	0.0122*	ND
Cobalt	mg/C	ND	ND	ND	ND	ND	ND
Copper	mg/t	ND	ND	ND	ND	ND	ND
Iron	mg/Ł	0.266*	ND	0.94*	ND	ND	ND
_ead	mg/£	ND	ND	ND	ND	ND	ND
Lithium	mg/L	ND	0.172*	0.028	.031*	0.0106*	ND
lagnes i um	mg/l	5.79*	15.3*	26.57	45.3*	9.41*	ND
langanese	mg/Ł	0.365	0.088*	0.686*	0.126*	0.292*	0.0182*
lercury	mg/L	ND	ND	0.003*	.008*	ND	ND
tolybdenum	mg/Ł	0.0136*	ND	ND	0.015*	0.015*	0.112*
Nickel	mg/L	0.0432*	ND	ND	ND	ND	ND
Potassium	mg/€	7.73*	ND	ND	ND	ND	21.89*
Selenium	mg/£	ND	ND	0.0114*	ND	ND	0.041*
Silver	mg/Ł	ND	ND	ND	ND	ND	ND
Sodium	mg/€	13.4	98.7*	88	36.9*	25.6*	599
Strontium	mg/£	0.159*	ND	ND	ND	ND	0.451*
Thallium	mg/ℓ	ND	ND	ND	0.01*	ND	ND
l'in	mg/ℓ	ND	ND	ND	ND	ND	
/anadium	mg/t	ND	ND	ND	ND	ND	ND
linc	mg/Ł	0.141*	ND	0.0212*	0.107*	ND	0.564

TABLE 2-3 (Continued)

BACKGROUND GROUND-WATER (ROUND 1) TOLERANCE INTERVAL UPPER LIMITS OR MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (11 Samples)	Colluvium (2 Samples)	Valley Fill Alluvium (8 Samples)	Weathered Claystone (4 Samples)	Weathered Sandstone (2 Samples)	Unweathered Sandstone (7 Samples)
Other							
Total Dissolved Solids	mg/Ł	352	520*	947	320*	170*	1761
Carbonate	mg/€	ND	ND (70+	ND	ND (00+	ND	49 412
Bicarbonate	mg/€	436 15.6	470* 20*	719 40.29	400* 11*	140* 15*	607
Chloride Sulfate	mg/t mg/t	45.1	86*	150	44*	16*	950
Nitrate	mg/£	2.98	0.18*	0.69*	0.58*	1.6*	0.610
Cyanide	mg/t	.0038*	ND	ND	0.0036*	ND	ND
pĤ		8.6 (5.98)	7.4* (7.1)**	8.68 (6.12)	8.2* (7.4)**	7.5* (7.2)**	10.57 (7.43)
Dissolved Radionuclides							
Gross Alpha	pCi/Ł	12.543	27*	13.515	12*	7*	13*
Gross Beta	pCi/L	14.570	12*	18.530	7*	2*	15*
Uranium 233, 234	pCi/t	1.647	11*	6.481	5.8*	1.1* 0*	12.936 0.135
Uranium 235 Uranium 238	pCi/t pCi/t	0.000 0.195	0.3* 7.7*	0.232 5.084	0.2* 3.2	0.6*	3.3507
Strontium 89, 90	pCi/t	0.552	0.1*	0.878	0.1	-0.1*	0.2*
Plutonium 239, 240	pCi/t	0.009	0*	0.012	0.03	0.01*	0.000
Americium 241	pCi/E	0.000	0*	0.012	0	0.01*	0.019
Cesium 137	pCi/L	0.603	0.2*	0.776	. 0.4	0.3*	0.7*
Tritium	pCi/L	309	100*	505	100	100*	731

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Maximum Detected Value

Minimum Detected Value

ND

TABLE 2-4

BACKGROUND SURFACE WATER (ROUNDS 1 and 2) TOLERANCE INTERVAL UPPER LIMITS OR MAXIMUM DETECTED VALUE

			7 samples)**
Analyte	Units	Total	Dissolved
	•		
<u>Metals</u>		•	
Atuminum	mg/l	0.916*	0.485*
Ant imony	mg/l	ND	ND
Arsenic	mg/l	· ND	ND
Barium	mg/l	ND	ND
Beryllium	mg/l	ND ,	ND
Cadmium	mg/l '	ND	ND
Calcium	mg/l	85.01	85.92
Cesium	mg/l	1.00*	ND
Chromium	mg/l	. ND	ND
Cobalt	mg/l	,ND	ND
Copper	mg/l	ND	ND
Iron	mg/l	3.17	1.78*
Lead .	mg/l	ND	0.006*
Lithium	mg/l	ND	ND
Magnesium	mg/l	.12.48	12.82
Manganese	mg/l	0.636	0.368*
Mercury	mg/l	0.001	0.001
Molybdenum	mg/l	ND	ND
Nickel	mg/l	ND	ND
Potassium	mg/l	ND	ND
Selenium	mg/t	ND	ND
Silver	mg/l	0.001*	ND
Sodium	, mg/l	47.36	46.22
Strontium	mg/l	0.382	0.40
Thallium	mg/l	ND	ND
Tin	mg/l	ND	ND
Vanadium	mg/l	ND	ND
Zinc	mg/l	0.027	0.032*

TABLE 2-4 (Continued)

BACKGROUND SURFACE WATER (ROUNDS 1 and 2) TOLERANCE INTERVAL UPPER LIMITS OR MAXIMUM DETECTED VALUE

Round 1 (7 samples)**									
Analyte .	Units	Total ·	Dissolved						
<u>Other</u>									
Total Dissolved Solids	mg/l	271.16	NA						
Carbonate	mg/l	ND	NA						
Bicarbonate	mg/l	296.97	NA						
Chloride	mg/l	106.9	NA						
Sulfate	mg/t	48.82	NA						
Nitrate	mg/t	2.69	NA						
Cyanide	mg/l	ND	NA						
рН		8.69 (6.60)	NA						
Radionuclides									
Gross Alpha	pCi/l	7.74	4.38						
Gross Beta	pCi/l	9.89	8.80						
Uranium 233, 234	pCi/l	1.45	1.40						
Uranium 235	pCi/l	0.133	0.133						
Uranium 238	pCi/l	0.803	0.957						
Strontium 89, 90	pCi/l	2.04	1.398						
Plutonium 239, 240	pCi/l	0.018	ND						
Americium 241	pCi/l	0.042	0.013	•					
Cesium 137	pCi/l	0.599	0.472						
Tritium .	pCi/l	258	NA						

NA - Not Analyzed ND - Not Detected

^{() -} Tolerance Interval Lower Limit for Two-Sided Parameter

⁻ Maximum Detected Value

At Stations SW-104 and SW-80, most total and a few dissolved constituents were uncharacteristically high relative to the other data.
 To be conservative, these data are not included in computation of the tolerance interval.

TABLE 2-5

BACKGROUND SEDIMENT TOLERANCE INTERVAL UPPER LIMITS OR MAXIMUM DETECTED VALUE

Analyte	Units	Upper Limit (9 Samples)
Total Metals		
Aluminum	mg/kg	24789
Antimony	mg/kg	ND
Arsenic	mg/kg	13.0*
Barium	mg/kg	182*
Beryllium	mg/kg	ND
Cadmium	mg/kg	ND
Calcium	mg/kg	72551
Cesium	mg/kg	ND
Chromium	mg/kg	43.38
Cobalt	mg/kg	ND
Copper	mg/kg	22.0*
Iron	mg/kg	28308
Lead	mg/kg	39.502
Lithium	mg/kg	· ND
Magnesium	mg/kg	4110*
Manganese	mg/kg	372.20
Mercury	mg/kg	ND
Molybdenum	mg/kg	ND
Nickel	mg/kg	29.9*
Potassium	mg/kg	ND ND
Selenium		ND
Silver	mg/kg	6.8*
Sodium	mg/kg	ND
Strontium	mg/kg	175*
Thallium	mg/kg	. ND
	mg/kg	
Tin	mg/kg	ND ST
Vanadium	mg/kg	50.2*
Zinc .	mg/kg	92.688
<u>Other</u>		
Nitrate	mg/kg	ND
Н		9.03 (8.77)
Total Radionuclides		
Gross Alpha	pCi/g	60
Gross Beta	pCi/g	50
Uranium 233, 234	pCi/g	1.669
Uranium 235	pCi/g	0.176
Uranium 238	pCi/g	1.755
Strontium 89, 90	pCi/g	1.390
Plutonium 239, 240	pCi/g	0.096
Americium 241	pCi/g	0.029
Cesium 137	pCi/g	1.578
	pCi/g	0.408

Not Detected Maximum Detected Value Tolerance Interval Lower Limit for Two-Sided Parameter

TABLE 2-6

BACKGROUND GEOLOGIC MATERIALS TOLERANCE INTERVAL UPPER LIMITS OR MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (70 Samples)	Colluvium (28 Samples)	Weathered Claystone (17 Samples)	Weathered Sandstone (4 Samples)
Total Metals					
Aluminum	mg/kg	25312	21663	13495	10300*
Antimony	mg/kg	ND	2 1003 ND	16.2*	ND
Arsenic	mg/kg	15.86	7.7	15.05	3.6*
Barium	mg/kg	155.8	345.8	240.1	165*
Beryllium	mg/kg	11.27	17.75	11.8	2.2*
Cadmium	mg/kg	3.2*	1.8*	ND	ND
Calcium	mg/kg	43079	20811	10183	5940*
Cesium	mg/kg	ND	274*	ND	ND ·
Chromium	mg/kg	37.9	26.8	16.57	10.7*
Cobalt	mg/kg	18.2*	15.9*	29.7*	20.5*
Copper	mg/kg	20.03	26.7	30.62	19.6*
Iron	mg/kg	22916	29991	41295	12300*
Lead	mg/kg	18.04	26.4	34.5	13.4*
Lithium	mg/kg	44.4	32.1	33.37	7.0*
Magnesium	mg/kg	4425	6151	4896	2520*
Manganese	mg/kg	422.9	545.1	656	305*
Mercury	mg/kg	0.58*	0.44*	0.35*	0.27*
Molybdenum	mg/kg	38.65	32.78	33.68	11.2*
Nickel	mg/kg	43.27	35.4	56.95	14.3*
Potassium	mg/kg	3336	2789	1400*	ND
Selenium	mg/kg	ND	ND	ND	ND
Silver	mg/kg	40.9*	33.5*	18.7*	12.7*
Sodium	mg/kg	ND	3680*	ND	ND ND
Strontium	mg/kg	226*	111.1	144.42	69.2*
Thallium	mg/kg	ND .	ND	ND	ND
Tin	mg/kg	338*	441*	274*	268*
Vanadium	mg/kg	54.67	58.2	47.7	22.2*
Zinc	mg/kg	52.64	98.1	106.7	79.9*

TABLE 2-6 (Continued)

BACKGROUND GEOLOGIC MATERIALS TOLERANCE INTERVAL UPPER LIMITS OR MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (70 Samples)	Colluvium (28 Samples)	Weathered Claystone (17 Samples)	Weathered Sandstone (4 Samples)
<u>Other</u>					
Sulfide Nitrate pH	mg/kg mg/kg	. 13* 4.3* 9.64 (6.06)	5* 4.274 9.48 (6.96)	5* 2.0* 10.14 (7.04)	2* 1.9* 9.2* (8.0)*
Total Radionuclides					
Gross Alpha Gross Beta Uranium 233, 234 Uranium 235 Uranium 238 Strontium 89, 90 Plutonium 239, 240 Americium 241 Cesium 137 Tritium	pCi/g	37.108 36.886 1.491 0.087 1.353 0.768 0.017 0.018 0.082	51.710 35.135 1.759 0.169 1.675 0.776 0.023 NR 0.113 0.299	52.302 35.743 1.985 0.258 1.643 0.786 0.020 NR ND 0.322	37 29 0.8 0.1 1.0 0.4 0.01 NR 0.0 0.39

ND - Not Detected

NR - Data Not Received

* - Maximum Detected Value

** - Minimum Detected Value

() - Tolerance Interval Lower Limit for Two-Sided Parameter

tolerance interval, this yields conservative interpretation of the site data. It is also noted that the upper limits

of the tolerance intervals are similar in magnitude to the maximum concentration observed for the data set.

2.3.2 Borehole Samples

The Phase I RI for OU No. 2 focused on source characterization of preliminarily identified past waste disposal

sites (IHSSs). Samples were taken from boreholes drilled into and adjacent to known IHSS locations and

analyzed for the parameters listed in Table 2-7. Boreholes were drilled into several IHSSs to the extent

practical. However, boreholes were not drilled into sites still containing wastes (the trenches) or radionuclide

contamination (903 Pad) because of potential health hazards to field workers and the potential for release of

waste constituents to the environment. Figure 2-1 shows Phase I RI borehole locations, and analytical soil

sampling results are presented in Appendix A.

The majority of the metals analyzed from subsurface materials at OU No. 2 were below background levels.

Those elements which did exceed background are discussed on a site-by-site basis in the subsequent sections.

Plutonium (Pu) and americium (Am) are the principal radionuclide contaminants exhibiting elevated

concentrations in surficial soils. Because many of the pedologic samples were mixed into large composites,

the Phase I RI data do not rule out the presence of radionuclides other than plutonium and americium.

Cesium-137 (Cs-137), tritium (H3), and uranium (U) were detected, albeit at near-background concentrations

and in fewer than 10 samples. The Phase I RI results are consistent with a recent aerial radiological survey

(EG&G, 1989). The radioactivity detected in that survey was associated with known radioactive material

storage and handling areas, and was attributed to plutonium, americium, and a uranium decay product. The

survey indicated elevated americium in borehole samples at the 903 Pad Lip Site. The cesium-137 activity was

at a level consistent with global fallout and not enriched in the Plant area. Planned Phase II sampling activities

will aid in evaluating the elevated plutonium and americium concentrations in surface soils and in boreholes.

The following sections summarize available subsurface soil sampling results for the 903 Pad, Mound, and East

Trenches Areas.

2.3.2.1 903 Pad Area

903 Drum Storage Site and 903 Pad Lip Site (IHSS Ref Nos. 112 and 155)

The 903 Pad Drum Storage and Lip Sites are considered together here because of the proximity of associated

boreholes (BH22-87, BH23-87, BH24-87, BH29-87, and BH30-87).

Rocky Flats Plant, Golden, Colorado eg&g\903pad\ou2-ph2\jly\sec-2.sep

TABLE 2-7

PHASE I RI **SOURCE SAMPLING PARAMETERS SOIL AND WASTE SAMPLES**

METALS

Hazardous Substances List - Metals Aluminum Antimony Arsenic Barium Beryllium Cadmium Calcium Chromium Cobalt Copper Iron Lead Magnesium Manganese Mercury Nickel Potassium Selenium Silver Sodium Thallium Tin Vanadium Zinc Other Metals

Chromium (hexavalent) Chromium (trivalent) Lithium Strontium

ORGANICS

Hazardous Substances List -- Volatiles . Chloromethane Bromomethane Vinyl Chloride Chloroethane Methylene Chloride Acetone Carbon Disulfide 1,1-Dichloroethene 1,1-Dichloroethane trans-1,2-Dichloroethene Chloroform 1,2-Dichloroethane 2-Butanone 1,1,1-Trichloroethane Carbon Tetrachloride Vinyl Acetate Bromodichloromethane 1,1,2,2-Tetrachloroethane 1,2-Dichloropropane trans-1,3-Dichloropropene Trichloroethene Dibromochloromethane 1,1,2-Trichloroethane Benzene cis-1,3-Dichloropropene

Sheet 1 of 4

TABLE 2-7 (Continued)

PHASE I RI SOURCE SAMPLING PARAMETERS SOIL AND WASTE SAMPLES

```
ORGANICS (CONT.)
       Hazardous Substances List - Volatiles (Continued)
               2-Chloroethyl Vinyl Ether
               Bromoform
               2-Hexanone
               4-Methyl-2-pentanone
               Tetrachloroethene
               Toluene
               Chlorobenzene
               Ethyl Benzene
               Styrene
               Total Xylenes
       Hazardous Substances List -- Semi-Volatiles
               N-Nitrosodimethylamine
               Phenol
               Aniline
               bis(2-Chloroethyl)ether
               2-Chlorophenol
               1,3-Dichlorobenzene
               1,4-Dichlorobenzene
               Benzyl Alcohol
               1,2-Dichlorobenzene
               2-Methylphenol
               bis(2-Chloroisopropyl)ether
               4-Methylphenol
               N-Nitroso-Dipropylamine
               Hexachloroethane
               Nitrobenzene
               Isophorone
               2-Nitrophenol
               2,4-Dimethylphenol
               Benzoic Acid
               bis(2-Chloroethoxy)methane
               2,4-Dichlorophenol
               1,2,4-Trichlorobenzene
               Naphtalene
               4-Chloroaniline
               Hexachlorobutadiene
               4-Chloro-3-methylphenol(para-chloro-meta-cresol)
               2-Methylnaphthalene
               Hexachlorocyclopentadiene
               2,4,6-Trichlorophenol
               2,4,5-Trichlorophenol
               2-Chloronaphthalene
               2-Nitroaniline
               Dimethyl Phthalate
               Acenaphthylene
               3-Nitroaniline
               Acenaphthene
               2,4-Dinitrophenol
               4-Nitrophenol
               Dibenzofuran
               2.4-Dinitrotoluene
               2,6-Dinitrotoluene
               Diethylphthalate
               4-Chlorophenyl Phenyl ether
               Fluorene
               4-Nitroaniline
```

Sheet 2 of 4

4,6-Dinitro-2-methylphenol

TABLE 2-7 (Continued)

PHASE I RI SOURCE SAMPLING PARAMETERS SOIL AND WASTE SAMPLES

```
ORGANICS (CONT.)
       Hazardous Substances List -- Semi-Volatiles (Continued)
               N-nitrosodiphenylamine
               4-Bromophenyl Phenyl ether
               Hexach Lorobenzene
               Pentachlorophenol
               Phenanthrene
               Anthracene
               Di-n-butylphthalate
               Fluoranthene
               Benzidine
               Pyrene
               Butyl Benzyl Phthalate
               3,3'-Dichlorobenzidine
               Benzo(a)anthracene
               bis(2-ethylhexyl)phthalate
               Chrysene
               Di-n-octyl Phthalate
               Benzo(b)fluoranthene
               Benzo(k)fluoranthene
               Benzo(a)pyrene
               Indeno(1,2,3-cd)pyrene
               Dibenz(a,h)anthracene
               Benzo(g,h,i)perylene
        Hazardous Substances List -- Pesticides/PCBS
               alpha-BHC
               beta-BHC
               delta-BHC
               gamma-BHC (Lindane)
               Heptachlor
               Aldrin
               Heptachlor Epoxide
               Endosulfan I
               Dieldrin
               4,4'-DDE
               Endrin
               Endosulfan II
               4,4'-DDD
               Endrin Aldehyde
Endosulfan Sulfate
               4,4'-DDT
               Endrin Ketone
               Methoxychlor
               Chlordane
               Toxaphene
               AROCLOR-1016
               AROCLOR-1221
               AROCLOR-1232
               AROCLOR-1242
               AROCLOR-1248
               AROCLOR - 1254
               AROCLOR-1260
       Other Organics
```

Sheet 3 of 4

Oil and Grease

TABLE 2-7 (Continued)

PHASE I RI SOURCE SAMPLING PARAMETERS SOIL AND WASTE SAMPLES

RADIONUCLIDES

Gross Alpha Gross Beta Uranium-233+234, 235 and 238 Americium-241 Plutonium-239+240

Strontium-239+20 Strontium-89+90 Cesium-137 Tritium

OTHER

рΗ

Sheet 4 of 4

Pre-Phase I RI 903 Pad Subsurface Radionuclide Investigations

Prior to the emplacement of the asphalt cover at the 903 Pad, a plutonium surface survey was conducted in

1968 subsequent to drum removal (Owen, 1968). The results of this survey are presented in Figure 2-6. This

survey indicates widespread contamination throughout the 903 Drum Storage Site. However, the highest

survey values occur beneath the western half of the pad where drums were stored and Building 903 was

located.

After the emplacement of the asphalt cover, the soils beneath the 903 Pad were sampled in two sampling

events for a total of 10 excavations. The purpose of both sampling events was the characterization of

plutonium and uranium concentrations beneath the Pad; other contaminants were not described. The

excavation locations are shown in Figure 2-7.

In the earlier of the two sampling events (Seed, et al., 1971), four excavation sites (Figure 2-8) were located

on the basis of a gross gamma survey on the asphalt cover. Four 2- to 4-square-foot holes were hand dug

to various depths. The total mass of plutonium yielded from excavations SW and NC were approximately 10

milligrams (mg) and 0.2 to 0.3 mg, respectively. Approximately 25 kg and 6 kg of depleted uranium were

recovered from excavations No. 14 and No. 17, respectively. (Depleted uranium is the uranium remaining after

the uranium-235 isotope is separated from natural uranium during the gaseous diffusion enrichment process.)

Reportedly, no sample contained both plutonium and uranium. Two conclusions are drawn from this study

pertinent to waste characterization. First, no evidence was found of radionuclides moving upward from the

original ground level into the fill material. Second, at all four locations activity extended no more than 1 inch

into a clay layer which was found 4 to 15 inches below the original ground surface. Table 2-8 presents a

summary of the results.

In the later sampling event (Navratil, et al., 1979), six soil samples (Table 2-9) were taken from beneath the 903

Pad. These soil samples were examined to determine the extent and distribution of plutonium and americium.

The average plutonium and americium concentrations reported for the six samples are shown in Table 2-9.

Pertinent conclusions drawn from this study are:

Plutonium and americium are associated with smaller soil fractions.

An estimated 18,000 tons of contaminated soil underlies the asphalt pad.

Tests conducted on 903 Pad soil indicate that wet screening is effective in reducing plutonium

and americium soil contamination (Navratil, et al., 1979).

Final Phase II RFI/RI Work Plan (Alluvial) - 903 Pad, Mound, and East Trenches Areas Rocky Flats Plant, Golden, Colorado eg&g\903pad\ou2-ph2\jly\sec-2.sep

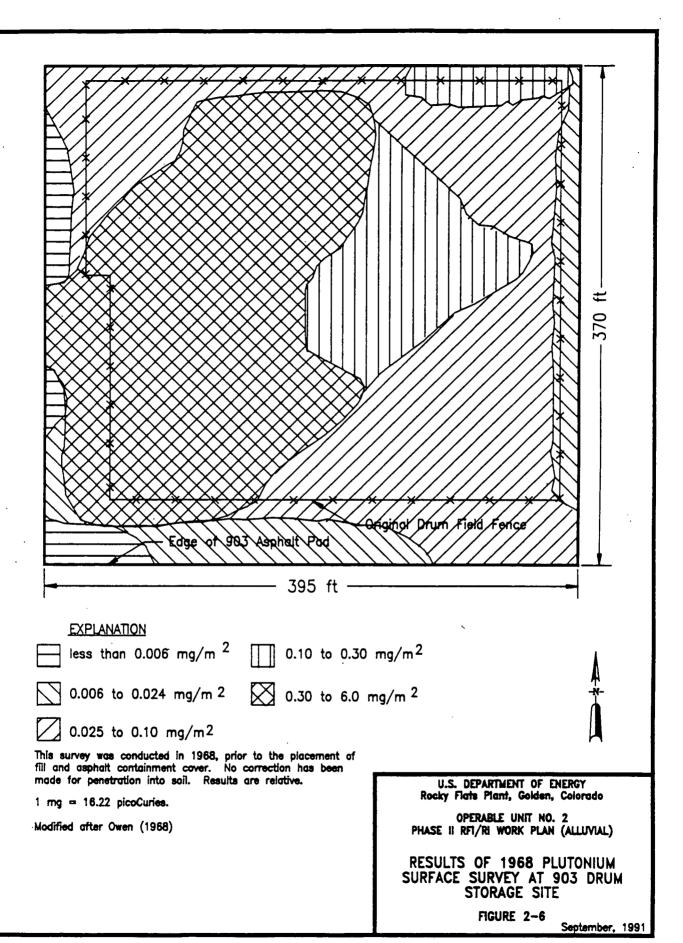


TABLE 2-8
SUMMARY OF RESULTS REPORTED BY SEED, ET AL. (1971)

Hole	Gamma Activity Thru Asphalt (cpm)	Maximum Gamma Reading in Hole (cpm)	Maximum or Reading in Hole (dpm)	Active Material	Where Activity First Detected	Vertical Thickness Activity Layer (inches) Below Original Ground Surface
No. 14*	55,000	3 x 10 ⁶	5,000	Depleted Uranium	Original Ground Layer	6-8
sw	16,000	<16,000	20,000	Plutonium	Original Ground Layer	4-6
No. 17	35.,000	2 x 10 ⁶	5,000	Depleted Uranium	Original Ground Layer	1-2
NC	16,000	20,000	1,000	Plutonium	Original Ground Layer	<1

Table modified after Seed, et al. (1971). Based on wet chemical analysis.

cpm = counts per minute

dpm = disintegrations per minute

This hole was identified as No. 32 in original table, however, review of text indicates this was mislabeled and should be hole No. 14 (no hole 32 was excavated).

TABLE 2-9
SUMMARY OF RESULTS FOR SOIL SAMPLING BENEATH THE 903 PAD

Radionuclide Content

_			Sampling Depth from			
Sample	Pu-239 dpm/g	pCi/g	Am-241 dipm/g	pCi/g	Ctil [±]	Top of Pad inches
1	940	427	620	282	46	18
2	1,400	636	1,100	500	61	24
3	8,000	3,636	1,000	455	56	22
4	45,000	20,455	4,200	1,909	66	26
5	14,000	6,364	4,100	1,864	61	24
6	17,000	7,727	5,000	2,273	61	24

Table modified from Navratil, et al. (1979)

dpm/g = disintegrations per minute per gram.

pCi/g = picoCuries per gram

cm = centimeters

The sampling depth shows the soil removal depth required to reach soil readings ≤250 dpm/g.

In summary, plutonium and americium are present beneath the 903 Pad and appear to be restricted to shallow depths

below the original ground surface. The distribution of other contaminants in the soils beneath the 903 Pad, however,

has not been investigated.

903 Pad and Lip Sites Phase I RI Soil Investigation Results

Hazardous Substances List (HSL) volatile organics, with the exception of bis(2-ethylhexyl) phthalate, were below

detection limits in boreholes surrounding the 903 Pad. Acetone and methylene chloride were reported but are

suspected laboratory artifacts as indicated by contaminated laboratory blanks. However, volatile organics are present

in ground water at the site and are expected to be present in subsurface materials directly beneath the 903 Pad.

Based on borehole sampling results, the extent of volatile organic soil contamination at the 903 Drum Storage Site

appears to be confined to the area immediately beneath and adjacent to the pad. Additional boreholes will be drilled

through and immediately adjacent to the pad during the Phase II RFI/RI to validate this conclusion.

The Rocky Flats Alluvium near the 903 Pad and Lip Sites contains barium (Ba), cadmium (Cd), calcium (Ca), mercury

(Hg), manganese (Mn), antimony (Sb), and zinc (Zn) above background. Of those elements, only manganese was

reported above background in more than two samples and by more than a factor of two above the tolerance limit

[maximum: manganese - 1,080 milligrams per kilogram (mg/kg) in BH23-87]. The isolated occurrence of detectable

mercury in colluvium is notable for its very high value (114 mg/kg in BH29-87).

Fewer analytes exceeded background in the deeper units below IHSSs 112 and 155. Cadmium reached 3.8 and 4.0

mg/kg in claystone, and the major ions calcium and aluminum (Al) exceeded background by less than 10 percent

of the tolerance level. Sandstone in BH29-87 exhibited arsenic (As), cadmium, and mercury slightly above

background, and iron (Fe), lead (Pb), and vanadium (V) above background by larger margins.

The Phase I RI results provide evidence of plutonium and americium contamination of surface soils. Plutonium and

americium are significantly elevated in the 0 to 1 foot composite interval of BH30-87 [plutonium -180 picoCuries per

kilogram (pCi/kg); americium - 22 pCi/kg], and less so in BH22-87 and BH23-87.

Based on results of a borehole sampling program (Rockwell International, 1987a), it appears that soil within the 903

Pad Lip Site is contaminated with plutonium, americium, and phthalates. Radionuclide contamination (plutonium and

americium) is apparently limited to surficial soils; however, this conclusion will be tested during the Phase II RFI/RI.

Final Phase II RFI/RI Work Plan (Alluvial) - 903 Pad, Mound, and East Trenches Areas Rocky Flats Plant, Golden, Colorado Technical Memorandum 1

Trench T-2 Site and Reactive Metal Destruction Site (IHSS Ref. Nos. 109 and 110)

Boreholes BH25-87 through BH28-87 are grouped here to jointly characterize the Trench T-2 and Reactive

Metal Destruction Sites. Volatile and semi-volatile organics were detected just south of Trench T-2 in borehole

BH25-87; maximum concentrations of detected compounds were 17,000 micrograms per kilogram ($\mu q/kq$) of

trichloroethene (TCE), 640 μ g/kg of toluene, 10,000 μ g/kg of PCE, 250 μ g/kg of 1,1,1-trichloroethane (1,1,1-

TCA), 1,900 μ g/kg of bis(2-ethylhexyl) phthalate, 780 μ g/kg of ethylbenzene, 3,300 μ g/kg of total xylenes, and

1,100 µg/kg of acetone (also detected in the blank). Chloroform (CHCl₂) and 2-butanone were estimated at

concentrations below the detection limit in two samples each. Solvent contamination was also found at the

eastern corner of Reactive Metal Destruction Site in BH28-87. PCE at 210 µg/kg, carbon tetrachloride (CCl_a)

at 100 $\mu q/kq$, bis(2-ethylhexyl) phthalate (3,400 $\mu q/kq$), and carbon disulfide at 58 $\mu q/kq$ were all detected

below the water table in BH28-87. Additional soil samples will be collected from this site during the Phase II

RFI/RI to fully characterize the extent of soil contamination.

Numerous samples contained arsenic and cadmium above background in the vicinity of Trench T-2 and the

Reactive Metal Destruction Site. Boreholes near T-2, BH25-87 through BH27-87, contained above-background

arsenic and cadmium in both colluvium and claystone, reaching a maximum of 20 mg/kg arsenic in claystone

at BH25-87 and 5.4 mg/kg cadmium in colluvium at BH27-87. Only one sample showed above-background

barium, but the margin above background was very large (1,899 mg/kg in BH25-87).

Calcium and potassium (K) exceeded background, but the margins of those major soil ions above tolerance

levels were ten percent or less. The sole occurrences of above-background nickel (Ni) (36.1 mg/kg in

BH25-87) and chromium (Cr) (17 mg/kg in BH27-87) were within one mg/kg of the respective tolerance limits.

Plutonium and americium were elevated above background in surficial materials near Trench T-2 (BH25-87,

BH26-87, BH27-87), and in surficial and bedrock materials near the Reactive Metal Destruction Site (BH28-87).

Additional planned surficial soil and soil profile sampling will characterize the radionuclide distribution more

thoroughly.

2.3.2.2 Mound Area

Mound, Oil Burn Pit, and Trench T-1 Sites (IHSS Ref. Nos. 113, 153 and 108)

Boreholes BH33-87 through BH38-87 are discussed together here to represent soils in the vicinity of the

Mound, Oil Burn Pit, and Trench T-1 Sites.

Rocky Flats Plant, Golden, Colorado eg&g\903pad\ou2-ph2\jly\sec-2.sep No volatile organic contamination was found in boreholes BH37-87 and BH38-87 at the Mound Site, but HSL

organics were present closer to Trench T-1 and the Oil Burn Pit [acetone, methylene chloride, 1,2-

dichloroethane (1,2-DCA), N-nitrosodiphenylamine, di-n-butyl phthalate, and bis(2-ethylhexyl) phthalate]. The

detected volatiles were all estimated at concentrations below the detection limit or were present in the

associated laboratory blanks at concentrations within a factor of two of the concentration in the sample (not

reportable following CLP protocol). Of the semi-volatiles listed above, only bis(2-ethylhexyl)phthalate was found

at non-estimated concentrations, and it was only slightly above the detection limits. There is inadequate

evidence to demonstrate significant organic contamination of soils in the vicinity of IHSSs 108 and 158;

however, additional soil samples will be collected in this area during the Phase II RFI/RI.

Major soil cations, calcium, magnesium, sodium, aluminum, and iron all occurred well above background in

alluvium of the Mound Area. Calcium was enriched by more than a factor of 10 in BH34-38. Copper (Cu) and

vanadium were above background in BH34-87, and cadmium occurred above background in BH33-87.

Selenium (Se) was above background in BH38-87 alluvium.

Major ions were less elevated in the claystone and sandstone than in upper units. Calcium and manganese

were above tolerance levels by a small margin in only one sample each in BH33-87 and BH37-87.

Arsenic and cadmium were above background in both lithologic units although the margins above background

were small. Barium was above background in claystone and lead was above background in sandstone.

Potassium was the only major element above background in the sandstone (maximum of 1,400 mg/kg in

BH45-87).

Plutonium and americium were elevated in composited pedologic samples adjacent to Trench T-1 (boreholes

BH35-87 and BH36-87). Plutonium was detected at 1.5 \pm 0.2 pCi/g, and americium was detected at 0.30 \pm

0.13 pCi/g in the 0 to 12 foot composite sample from borehole BH35-87. Plutonium was also detected at 0.53

± 0.16 pCi/g in borehole BH36-87 (0 to 5 foot composite sample). Since radionuclide contamination is limited

to soil samples that include the ground surface, wind dispersal of plutonium and americium from the 903 Drum

Storage Site is the likely source of these contaminants. This hypothesis will be addressed in the draft RFI/RI

Report.

Additional soil sampling of the surface materials will be performed in the Mound Area to identify possible

impacts of radionuclide contamination resuspended from the 903 Drum Storage Site. Based on review of

historical air photos, the Mound Site location was revised westward during preparation of the Phase I RI report.

Additional boreholes are needed in the revised IHSS location.

Pallet Burn Site (IHSS Ref. No. 154)

Soil organic contamination is apparent at IHSS 154. Maximum organic compound levels in borehole BH31-87 were 580 μ g/kg of bis(2-ethylhexyl) phthalate, 32 μ g/kg of 1,2-DCA, 110 μ g/kg of acetone, and 20 μ g/kg of PCE. Maximum organic compound concentrations in borehole BH32-87 were 310 μ g/kg bis(2-ethylhexyl) phthalate, 29 μ g/kg of 1,2-DCA, and 170 μ g/kg of acetone. No other organic contaminants were detected, and no metals were reported above background in BH31-87 and BH32-87. Soil sampling is needed to evaluate the depth and extent of the plutonium in soils. Furthermore, review of aerial photographs and historical documents during the Phase I RI resulted in revision of the Pallet Burn Site location as discussed in Section 2.0. Additional soil samples will therefore be collected from a boring in the possible eastern location of the Pallet Burn Site during Phase II activities.

2.3.2.3 East Trenches Area

Trenches T-3, T-4, T-10, and T-11 (IHSS Ref. Nos. 110, 111.1, 111.7, and 111.8)

Characterization of the northern East Trenches (T-3, T-4, T-10, and T-11) is based on soil sampling results from boreholes BH39-87 through BH46-87.

Three of the seven boreholes near Trenches T-3, T-4, T-10 and T-11 (BH39-87 through BH46-87) exhibited volatile organics above detection limits. Maximum concentrations of 1,1,1-TCA were 130 μ g/kg in BH43-87, 180 μ g/kg in BH45-87, and 190 μ g/kg in BH46-87. Numerous occurrences of acetone, 2-butanone, and methylene chloride ranged up to several hundred micrograms per killogram. In BH39-87 through BH43-87 the acetone results did not have associated laboratory blank contamination and therefore may reflect actual contamination. N-nitrosodiphenylamine was present at estimated concentrations below 100 μ g/kg.

Several occurrences of bis (2-ethylhexyl) phthalate were found in samples from boreholes at Trenches T-3, T-4, T-10, and T-11. The maximum concentration of 880 μ g/kg occurred in BH45-87 (0 to 9.5 foot interval). In addition, four detects for di-n-butyl phthalate are found in the analytical data; however, all were estimated at concentrations below the detection limit, and two of these detected were also present in the associated laboratory blanks (Appendix A).

Calcium was the only major ion in alluvium that was present above background. Its concentration in BH41-87, BH43-87, and BH45-87 ranged between 50,000 and 120,000 mg/kg, well above the tolerance limit of 43,079 mg/kg. All of the boreholes contained up to three trace elements above background except BH44-87. Maximum valves were: arsenic — 37 mg/kg in BH39-87; cadmium — 6.2 mg/kg in BH39-87; manganese — 58 mg/kg in BH42-87; zinc — 55mg/kg in BH41-87; and chromium — 58 mg/kg in BH43-87.

In the underlying claystone, sodium was the only major ion above background (maximum of 1,400 mg/kg in 39-87). Boreholes BH40-87, BH42-87, and BH44-87 had no elements above background, whereas BH39-87, BH41-87, BH43-87, BH45-87, and BH46-87 each had a few elements above background. Maximum values were: arsenic — 25 mg/kg in BH39-87; cadmium — 6.2 mg/kg in BH46-87; barium — 413 mg/kg in BH39-87; manganese — 3,540 mg/kg in BH45-87; vanadium — 60 mg/kg in BH45-87; and zinc — 124 mg/kg in

BH46-87.

Potassium was the only elevated major element in the sandstone (maximum of 1,400 mg/kg in BH45-87), and BH40-87, BH41-87, BH43-87, and BH46-87 had no metals above background. A subset of arsenic, barium, cadmium, chromium, iron, manganese, nickel, lead, and vanadium were elevated in each of boreholes BH49-87, BH42-87, BH44-87, and BH45-87.

Plutonium was elevated in the surface sample from BH39-87 (0.82 \pm 0.12 pCi/g). Additional surficial soil sampling is necessary within this group of trenches to characterize surficial radionuclide contamination.

Trenches T-5 through T-9 (IHSS Ref. Nos. 111.2 through 111.6)

Characterization of the southern East Trenches (T-5 through T-9) is based on soil sampling results from boreholes BH47-87 through BH54-87.

Volatile organic contaminants (including acetone and methylene chloride), bis(2-ethylhexel) phthalate, and N-nitrosodiphenylamine are present in alluvium and claystone in the vicinity of the southern trenches. Most of these occurrences are associated with contaminated laboratory blanks, but occasionally substantial concentrations were reported without a corresponding occurrence in the blanks. BH47-87, BH49-87, BH50-87, BH52-87, and BH54-87 contain 1,2-DCA (maximum 110 μ g/kg), TCE (maximum 150 μ g/kg), PCE (maximum 62 μ g/kg), and toluene (30 μ g/kg). Total xylenes (BH54-87, 2.0 to 4.0 foot interval) and 1,1,1-TCA (BH47-87, 8.0 to 9.0 foot interval) were reported at a concentration below the detection limit.

Major ions, calcium, magnesium, iron, and potassium were present above background in alluvium near Trenches T-5 through T-9. Only calcium was significantly elevated in more than one borehole (BH47-87, BH48-87, BH52-87, BH53-87, BH55-87, and BH56-87).

Only BH49-87 had no trace elements above background. In the other boreholes, arsenic, cadmium and lead were above background in a total of eight samples (maximum: arsenic — 30.8 mg/kg in BH54-87; cadmium — 5.6 mg/kg in BH51-87; and lead — 45.6 mg/kg in BH51-87).

Arsenic and cadmium were the only elevated metals in the sandstone beneath T-5 through T-9, and they each

exceeded background by only 0.2 mg/kg and in only one sample.

Plutonium was detected in the majority of the uppermost soil samples (maximum was 6.0 \pm 0.2 pCi/g in

BH52-87, 0 to 9.5 foot interval), and in only two subsurface samples (0.98 \pm 0.24 pCi/g, 2 to 3.5 foot interval,

and 0.14 \pm 0.12 pCi/g, 6 to 7.8 foot interval in BH53-87). Americium was detected only in BH52-87 (0.14 \pm

0.10 pCi/g, 0 to 9.50 foot interval) and BH53-87 (0.53 \pm 0.20 pCi/g, 0 to 18.8 foot interval) surface composites.

2.3.3 Ground Water

Ground-water samples from the 903 Pad, Mound, and East Trenches Areas were analyzed for the parameters

listed in Table 2-10. The following discussion of volatile organics, metals, and inorganics focuses on results

for the second quarter of 1989. These are the most recent data pertaining to the same season for which the

background data are available. However, the discussion of 1989 site-specific radionuclide data relies on first

quarter results because complete second quarter site-specific data are unavailable.

Site-specific results are compared to the upper limit of the tolerance interval when available. Maximum

detected values are used for comparison where there are insufficient data to calculate tolerance intervals. This

condition resulted from either an insufficient number of samples or an insufficient number of detectable

concentrations for a given analyte.

Appendix B presents all the ground-water quality data for OU No. 2 wells since remedial investigation sampling

began in late 1986 through second quarter 1989 (same data set as was used in the December 1989 submittal).

Quarterly ground-water sampling is ongoing at OU No. 2. These longer term data are consistent with the

findings in second quarter 1989 unless otherwise noted below. Data value qualifiers are presented in the

appendices and on the tables in the following sections. A "J" or an "E" next to an analyte concentration reflects

that the concentration is estimated below and above the detection limit, respectively.

2.3.3.1 Volatile Organic Contamination

Carbon tetrachloride, PCE, and TCE are the primary volatile organic contaminants in the unconfined ground-

water flow system. Figures 2-8 through 2-10 show isopleths for these compounds in the second quarter 1989

for both unconfined alluvial and bedrock wells. Table 2-11 presents all volatile organics above detection limits

in the unconfined ground-water system. Additional monitoring wells have been proposed for the 903 Pad,

Mound, and East trenches areas to define the extent of volatile organics in alluvial ground water and to

characterize alluvial ground-water flow. The purpose and location of each proposed well are presented in

Section 5.1.1.

TABLE 2-10

PHASE I RI GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

FIELD PARAMETERS

pH Specific Conductance Temperature Dissolved Oxygen

INDICATORS

Total Dissolved Solids Total Suspended Solids

METALS"

Hazardous Substances List - Metals Aluminum Ant imony Arsenic Barium Beryllium Cadmium Calcium Chromium Cobalt Copper Iron Lead Magnesium Manganese Mercury Nickel Potassium Selenium Silver Sodium Thallium Tin

Other Metals Chromium (hexavalent) Lithium Strontium

ANIONS

Vanadium Zinc

Carbonate Bicarbonate Chloride Sulfate Nitrate

ORGANICS

Oil and Grease
Hazardous Substances List - Volatiles
Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
trans-1,2-Dichloroethene
Chloroform

Sheet 1 of 2

TABLE 2-10 (Continued)

GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

ORGANICS

Hazardous Substances List - Volatiles (Continued) 1.2-Dichloroethane 2-Butanone 1,1,1-Trichloroethane Carbon Tetrachloride Vinyl Acetate Bromodichloromethane 1,1,2,2-Tetrachloroethane 1,2-Dichloropropane trans-1,3-Dichloropropene Trichloroethene Dibromochloromethane 1,1,2-Trichloroethane Benzene cis-1,3-Dichloropropene 2-Chloroethyl Vinyl Ether Bromoform 2-Hexanone 4-Methyl-2-pentanone Tetrachloroethene Toluene Chlorobenzene Ethyl Benzene Styrene Total Xylenes

RADIONUCLIDES

Gross Alpha Gross Beta Uranium-233+234, 235, and 238 Americium-241 Plutonium-239+240 Strontium-90 Cesium-137 Tritium

* For surface water samples only

** Dissolved metals for ground-water samples, total and dissolved metals for surface water samples

*** Ground-water samples from the first quarter of 1987, and all surface water samples were analyzed for

9 of the HSL volatiles. These volatiles are the chlorinated solvents historically detected in the

ground water and are as follows: PCE, TCE, 1,1-DCE, 1,2-DCA, t-1,2-DCE, 1,1,1-TCA, 1,1,2-TCA, CCl₄

and CHCl₂.condition resulted from either an insufficient number of samples or an insufficient number

of detectable concentrations for a given analyte.

. Sheet 2 of 2

TABLE 2-11

VOLATILE ORGANIC COMPOUNDS DETECTED IN THE UPPER HYDROSTRATIGRAPHIC UNIT GROUND WATER SECOND QUARTER 1989

Matrix	<u>Well</u>	Date Sampled	Carbon Tetra- chloride (µg/l)	Tetra- chloro- ethene <u>(#9/L)</u>	Trichloro- ethene <u>(#9/2)</u>	Chloro- form (#9/L)	Methylene Chloride (#g/l)	1,1-Di- Chloro- ethane _(#g/l)	1,1-Di- Chloro- ethene <u>(#9/L)</u>	Vinyl Chloride <u>(#g/l)</u>	Acetone (#g/L)	Carbon Disulfide (#9/L)	Total-1,2- Dichloro- ethene (#9/€)	Toluene (#g/l)
Rocky Flats Alluvium	33-86 39-86 41-86	5/04/89 5/08/89 5/10/89	Dry											
Attovian	42-86 43-86 10-87	5/08/89 5/04/89 5/02/89	1,100 Dry Dry	300	190	21J								
	15-87 17-87 19-87	5/01/89 5/03/89 5/04/89	1,100J 47J Dry	190 160R	120 17	· 21 4J			5J					
	24-87 26-87 27-87	5/09/89 5/09/89 5/10/89	Dry Dry 15	31	4.J	3 J								
	32-87 33-87 35-87	5/09/89 5/09/89 5/09/89	Dry Dry Dry									,		
Colluvium	63-86 67-86 29-87	4/13/89 5/09/89 4/24/89	Dry Dry											
	44-87	4/13/89	Dry											
Valley Fill Alluvium	35-86 36-86 37-86	5/03/89 5/04/89 5/03/89		30R	11			59	13	470			3J	
	64-86 65-86 66-86 21-87	5/31/89 4/13/89 6/02/89 5/03/89		8J		26	1,				2J	31		

TABLE 2-11 (Continued)

VOLATILE ORGANIC COMPOUNDS DETECTED IN THE UPPER HYDROSTRATIGRAPHIC GROUND WATER SECOND QUARTER 1989

Matrix	<u>Well</u>	Date <u>Sampled</u>	Carbon Tetra- chloride (#g/l)	Tetra- chloro- ethene (#g/L)	Trichloro- ethene (#9/£)	Chloro- form (#g/l)	Methylene Chloride (#g/l)	1,1-Di- Chloro- ethane (#g/L)	1,1-Di- Chloro- ethene <u>(#9/L)</u>	Vinyl Chloride <u>(#9/l)</u>	Acetone _(#9/L)	Carbon Disulfide (#9/2)	Total-1,2- Dichloro- ethene (#9/£)	Toluene <u>(#a/l)</u>
Weathered Claystone	1-71 2-71 1-74 3-74	5/01/89 5/01/89 5/03/89 5/08/89	690J 1,100	69 8 45,000 50	230 440 1,800 25	200 7 11J		8	5.1					
Weathered Sandstone	62-86 9-87 11-87 12-87 14-87 23-87 25-87 36-87	4/17/89 5/01/89 5/02/89 5/02/89 4/24/89 5/03/89 5/08/89 5/08/89	Dry Dry 160J 290 610	4J 74R 840 350E	68 120 12,000	16 5J 290E			22 J		2JB			21

Value estimated below detection limit

Value estimated

Value rejected by data validation Compound also detected in associated blank.

Carbon Tetrachloride

Carbon tetrachloride occurs in ground-water monitoring wells east, southeast, and northeast of the 903 Pad

Area (Figure 2-8). Of the downgradient wells in this area, 1-71 and 15-87 show the highest levels of CCl₄ [690J

and 1,100J micrograms per liter $(\mu g/l)$]. (These relatively high concentrations of CCl₄ are flagged "J" because

the measurement of the undiluted samples exceeded the range of the standard curve, and the laboratory

diluted samples were less than the range of the standard curve. Although this compromises the precision of

the data, these results indicate that significant CCI, contamination exists.) The northern East Trenches may

be a second source of CCl_a, for the downgradient concentrations (in wells 36-87 and 42-86) are greater than

the upgradient concentrations (in wells 17-87 and 25-87).

The data from repeated samplings corroborate the second quarter 1989 findings, with CCl₄ concentrations of

several hundred to a few thousand $\mu g/\ell$ in the majority of samples from wells 42-86, 15-87, 17-87, 1-71, 3-74,

11-87, 14-87, 25-87, and 36-87. Other wells had high but isolated CCl₄ readings (for example, 2,292 μ g/ ℓ in

39-86), low but consistent readings (in wells 29-87 and 12-87) less than 100 μ g/ ℓ , and one low occurrence in

well 35-87 (12 mg/ ℓ). These data demonstrate that CCl₄ has penetrated all sampled geologic units except

unweathered sandstone. Although CCI₄ was not detected in the Mound Area at well 1-74, the existing well

network is not sufficient to define in detail the CCI₄ plume.

Tetrachloroethene

The Mound Area appears to be the primary source of PCE within the study area (Figure 2-9) as well 1-74

contained 45,000 μ g/ ℓ PCE. A plume of PCE with concentrations greater than 100 μ g/ ℓ extends east and

southeast (downgradient) from the Mound Area to at least well 36-87. The extent of this plume is not well

defined.

PCE was detected in wells southeast (downgradient) of the 903 Pad and Trench T-2 (2-71, 15-87, and 1-71),

although the concentrations were lower than in the Mound Area wells. An estimated concentration of 8J $\mu g/\ell$

at well 64-86 is the only PCE occurrence outside the limits defined by the wells listed above. This low and

isolated result does not provide adequate evidence of PCE contamination at well 64-86. Additional monitoring

wells and further sampling are required to delineate the extent of PCE contamination in this vicinity.

Nearly all of the wells that contained PCE in second guarter 1989 exhibited that contaminant throughout the

historical samplings. PCE was reported as high as 528,000 $\mu g/\ell$ in well 1-74. The earlier sampling also

suggests that the PCE plume may extend farther than shown on Figure 2-10, for occasional samples from wells

39-86, 41-86, 32-87, and 29-87 had PCE concentrations above detection limit. Historical sporadic occurrences

of PCE in unweathered sandstone (wells 40-86, 18-87, and 20-87) also may indicate more extensive

contamination than implied by second quarter 1989 data alone.

Trichloroethene

The distribution of TCE (Figure 2-10) indicates that all three RI areas are sources of this volatile organic. TCE

in wells 1-71, 2-71, 14-87, and 15-87 suggests the upgradient 903 Drum Storage Site, and possibly Trench T-2

and the Reactive Metal Destruction Site, as potential sources. Similarly, TCE in wells 1-74, 17-87, and 35-86

suggests the Mound Area as a source, and TCE downgradient of Trenches T-3 and T-4 also indicates these

East Trenches as potential sources. Well 36-87 within the latter area exhibited the highest concentration

 $(12,000 \mu g/l)$.

The 1987-89 data are consistent with results shown in Figure 2-10, exhibiting detectable TCE in nearly all

samplings of the wells listed above. Furthermore, four wells which were not explicitly listed for 1989 did contain

TCE at several previous samplings (39-86, 32-87, 11-87, and 12-87). Isolated occurrences of TCE, together

with the PCE data for unweathered sandstone wells 40-86, 18-87, and 20-87, suggest that even these bedrock

units may be contaminated by volatile organics.

Other Volatile Organic Compounds

Indication of other volatile organic contamination in ground water by second quarter 1989 data are confirmed

by the more comprehensive 1987-89 results. Vinyl chloride was present during six sampling events at well 35-

86 northwest of the Mound Area in concentrations between 400 and 1,000 μ g/ ℓ . 1,1-dichloroethene (1,1-DCE)

appeared consistently in wells 35-86 and 1-71, and occasionally in wells 2-71, 1-74, and 36-87. The highest

1,1-DCE result was 1,044 μ g/ ℓ in well 36-87. 1,1-dichloroethane (1,1-DCA) appeared as frequently but in lower

concentrations than 1,1-DCE in wells 35-86 and 2-71.

Chloroform CHCl, occurred in the majority of samples from wells 42-86, 15-87, 17-87, 2-71, 11-87, 14-87, and

36-87, commonly in association with other volatile organics. The CHCl, concentrations were typically over 100

 $\mu g/\ell$, and reached as high as 5,427 $\mu g/\ell$ in 36-87. CHCl₁ is also reported in two unweathered sandstone

wells, 28-87 and 30-87, but these are isolated instances at low concentrations in the absence of other organics.

Additional data are required to assess the significance of these values.

Two wells at OU No. 2 contained 1,1,1-TCA at times in the past (11-87 and 36-87). The highest concentration

was 1,472 μ g/ ℓ at 36-87.

Methylene chloride and acetone were 119 and 38 μ g/ ℓ , respectively, at well 36-87. The relatively high concentration of these constituents, together with their association with several other organics in well 36-87, suggest that they are ground-water contaminants in the sandstone unit. However, in other upgradient or surrounding wells, numerous other reports of methylene chloride and acetone are associated with their occurrence in laboratory blanks, and/or their concentrations are very near the detection limits. Such conditions apply to samples from wells 41-86, 17-87, 27-87, 32-87, 35-86, 2-71, 14-87, 20-87, and 31-87, and do not reliably indicate ground-water contamination with these volatiles. Further sampling and analysis is necessary to resolve if methylene chloride and acetone are present at well 36-87.

2.3.3.2 Inorganic Contamination

Major Ions

Major ions and total dissolved solids (TDS) are somewhat elevated above background throughout and downgradient of the 903 Pad, Mound, and East Trenches Areas (Tables 2-12A and 2-13A through F). Tables 12A through C tabulate inorganic, dissolved metal, and dissolved radiochemistry concentrations, respectively, that exceeded background values in ground water during the second quarter of 1989. Tables 13A through F, 14A through F, and 15A through F list the maxima and frequency of inorganic, dissolved metal and dissolved radiochemistry concentrations, respectively, exceeding background values in ground water detected during sampling in 1987 through 1989. Background figures presented for comparison (Tables 2-12A and 2-13A through F) to all previously collected data may not represent background for quarters other than the second quarter of 1989, therefore, this table serves as a qualitative comparison only. Total dissolved solids typically ranged between 400 and 1,000 milligrams per liter (mg/ ℓ); chloride was generally 30-100 mg/ ℓ , nitrate was 2-10 mg/ ℓ , and most sulfate concentrations were between 10 and 100 mg/ ℓ in the second quarter of 1989. In general, major cations were accordingly elevated. The highest concentrations of major ions are in well 29-87 southeast of the 903 Pad as discussed below, although TDS at the northernmost well (35-87) was also elevated above background.

Major ions in 29-87, a well completed in colluvium southeast of the 903 Pad, were notably higher than other shallow ground-water wells upgradient and closer to the 903 Pad (Table 2-12A). (TDS - 3,219 mg/ ℓ ; chloride - 819 mg/ ℓ ; sulfate - 891 mg/ ℓ ; calcium - 279 mg/ ℓ ; sodium - 353 mg/ ℓ ; and magnesium - 105 mg/ ℓ .) The conditions at well 29-87 suggest that the ground-water chemistry there may be strongly influenced by evaporation and associated accumulation of salts. It may be, in effect, in a "saline seep" zone (Miller, et al., 1980). The SID is very close to well 29-87; when it recharges local ground water it carries SID salts (in relatively dilute form) and mobilizes salts as it passes through soils (typical regional soils have not been leached of all naturally occurring salts). Subsequent repetitive seasonal evaporation of ground water at

TABLE 2-12A

INORGANIC CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER SECOND QUARTER 1989

Area	Well	T.D.S.	Chloride	Nitrate/	Sulfate	Bicarbonate	Carbonate	Cyanide
ROCKY FLATS ALLUVIUM	BACKGROUND->	352 DRY	15.6	2.98	45.1	436	ND	.0038*
	39-86 41-86 42-86 43-86 10-87	NSS 482 476 DRY DRY	40.0 49.5	7.89 4.39	59.6		NR NR	NR NR
	15-87 17-87 19-87 24-87 26-87	NSS 405 DRY DRY ORY	37.1				NR	NR .
	27-87 32-87 33-87 35-87	439 DRY DRY DRY	34.6	8.42	61.5		NR	NR '
COLLUVIUM	BACKGROUND->	520*	20*	0.18*	86*	470*	ND	ND
	63-86 67-86 29-87 44-87	DRY DRY 3219 DRY	819	.74	891	719	NR	NR
VALLEY FILL	BACKGROUND->	947	40.3	0.69*	150	719	ND	NO
ALLUVIUM	35-86 36-86 37-86	990 ORY NSS	99.2			768	NR	NR
	64-86 65-86 66-86 21-87	DRY	76	NR	290		NR	NR NR
WEATHERED	BACKGROUND->	320*	11*	0.58*	44*	400*	ND	.0036*
CLAYSTONE	1-71 2-71	NCC	18.1	4.99			NR	
	1-74 3-74	NSS 397 NSS	24.1	6.03		,	NR	NR
WEATHERED SANDSTONE	BACKGROUND->	170*	15*	1.6*	16*	140*	ND	ND
	62.86 9-87 11-87 12-87	277 271 DRY DRY	29.1	2.27 2.35	52.3 36.1	184	6.93 NR	NR NR
	14-87 23-87 25-87 36-87	288 421 482 486	32.0 62.6 41.1 38.3	1.73 2.44 7.11 7.95	47.2 18.6 27.9 25.0	141 259 261 281	15.9 NR NR NR	NR NR NR NR
UNWEATHERED SANDSTONE	BACKGROUND->	1761	607	0.61	950	412	49	ND
SANDSTONE	34-86 40-86 16-87		*******	1.33 2.02		•••••	NR NR	NR NR
	18-87 20-87 22-87	NSS NSS	•					
	28-87 30-87	NSS					3.14	NR
	31-87 34-87	NSS					15.2	NR
	45-87						NR	NR



DISSOLVED METAL CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER SECOND QUARTER 1989

Area	Well	<u>Al</u>	Sb	As	Ba	Cd	Ca —	Cr	Cu	Pe	Pb	Li	Mg	Mn	Мо	Ni ——	<u>K</u>	Se	Ag	Na	Sr	<u>v</u>	Zn
ROCKY FLATS ALLUVIUM	BACKGROUND->	ND	ND	ND	ND	ND	85	ND	ND	.266*	ND	ND	5.79*	. 365	.0136*	.0432*	7.73*	ND	ND	13.4	. 159*	ND	0.141*
	33-86 39-86 41-86 42-86 43-86	DRY			.23 .23		112 125 154		. 05				12.1 17.1 13.5							18.9 21.3 17.8	. 55 . 66 . 57		,
	10-87 17-87 19-87 24-87	DRY DRY DRY			. 12J		105		.02J				9.5			.047				16.5	. 45		
	26-87 27-87 32-87 33-87 35-87	DRY DRY DRY DRY			. 138		90		.018				15.8			٠				30.1	.60		
COLLUVIUM	BACKGROUND->	ND	ND	ND	ND	ND	77*	ND	ND	ND	ND	.172*	15.3*	.088*		ND	ND	ND	ND	98.7	ND	ND	ND
	63-86 67-86 29-87 44-87	DRY DRY			.048		279		.01В		NR	NR	105		.038	0.42		. 388		353	3.94		. 11
VALLEY FILL ALLUVIUM	BACKGROUND->	ND	ND	ND	ND	ND	138	ND	ND	0.94*	ND			0.69*	ND	ND	ND	.011*		88	ND	ND	.021*
	35-86 36-86 37-86 64-86 65-86	.04J DRY NSS NSS DRY .05	,	.0013	.12J		143	*****			*****	NR NR	33.7	4.37		.03J	.97J		••	193	.88		.029
	21-87	NSS																					
WEATHERED CLAYSTONE	BACKGROUND->		ND	ND	ND	ND	73.4*	ND	ND	ND	ND		45.3*	.013*	.015*	ND	ND	ND	ND	36.9*		ND	. 107*
	1-71 2-71 1-74 3-74	.03B NSS .035J NSS			. 35 . 17 J		88					NR NR		.17		. 03 J	1.35J .72J				. 54 . 49		
WEATHERED SANDSTONE	BACKGROUND->		ND	ND	ND	ND	65.7*	.012*	ND	ND	ND	.0106	9.41*	.292*	.015*	ND	ND	ND	ND	25.6*	ND	ND	ND
	62-86 9-87 11-87 12-87	.02J DRY DRY	•		.04J	.009A	83.3	. 034	.005J			NR NR	10.0				3.63	.049		51.6	.41		
	14-87 23-87 25-87 36-87	.036J .04 .02B		1.6J	. 17 J . 22 . 26		111 131 116	.02	.0088	.03		NR NR NR NR	10.4 13.0				5.33 1.66J 1J 0.9	.014		89.5	. 42 . 55 . 41 . 29		
UNWEATHERED SANDSTONE	BACKGROUND->		ND	.019*	ND	ND	64.6	ND	ND	ND	ND	ND	ND	.018*	.112*		21.9*	.041*	ND	599	.45*	ND	.56
3KND3 FORE	34-86 40-86		NR		.033		224			2.17		NR NR	71.7	. 123			•••••	.22J		•••••	2.99	ND	. 56
•	16-87 18-87 20-87	NSS NSS			.048							NR	6.01					. 2.2.5			. 33		
	22-87 28-87 30-87 31-87				.04J .18B						.21J	NR NR NR NR	17.5 3.51J 1.44J	.045							. 89		
	34-87 45-87	NSS			.65J							NR	9.8	0.40							. 48		

TABLE 2-12C

DISSOLVED RADIOCHEMISTRY CONCENTRATIONS (PCI/L) EXCEEDING BACKGROUND IN GROUND WATER SECOND QUARTER 1989

				PECOND COMITEN				
Area	Well	Alpha	Beta	U233,U234	U235	U238	Pu239,Pu240	Am241
								
OCKY FLATS	BACKGROUND->	12	15	1.6	0	1.2	.01	0
VECUVIUM	33-86 39-86	DRY NSS		*			******	******
	39-86 41-86			2.9 3.9	.07 .06	1.9 2.3		
	42-86 43-86 10-87	DRY DRY		2.4	. 05	1.5		
	15-67 17-87 19-87	DRY DRY		1.7	.03	1.3		
	24-87 26-67 27-87	DRY DRY DRY		·				
	32-87 33-87	DRY		3.4	.05	1.6		,
OLLUVIUM	33-87 BACKGROUND->	DRY 27*	12*	11*	0.3*	7.7*	0*	0*
	63-86 67-86	DRY				*******		
	29-87 44-87	DRY		NR	NR	NR		
ALLEY FILL	BACKGROUND->	14	19	6.5	0.2	5.1	.01	0.01
	35 - 86 36 - 86 37 - 86 64 - 86 65 - 86 66 - 88	DRY						NR
	21-67	NSS						
EATHERED LAYSTONE	BACKGROUND->	12*	7 * 	5.8* NR	.2* NR	3.2 NR	.03	0
	2-71 1-74 3-74	NSS NSS DRY			NK.	,		
EATHERED SANDSTONE	BACKGROUND->	7.	2*	1.1*	0*	0.6*	.01*	.01*
MINDSTONE	62-86 9-87 11-87	NR DRY	NR	NR 1.1	NR . 04	NR . 67	NR	NR
	12-87 14-87	DRY		1.8	. 05	1.3		
	23-87 25-87 36-87		4	3.3 1.8 2.3	.09 .09 .03	2.1 .92 .98		
NWEATHERED ANDSTONE	BACKGROUND->	13*	15*	13	.1*	3.4	0	0.02
	34-86 40-86 16-87	NSS				*****		******
	18-87 20-87	NSS NSS						
	22-87 28-87 30-87	NSS						
	31-87 34-67	NSS						

TABLE 2-13A

ROCKY FLATS ALLUVIUM MAXIMA AND FREQUENCY OF INORGANIC CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		T.D.S.	Chloride	Nitrate/ Nitrite	Sulfate	Bicarbonate	Carbonate	Cyanide
	BACKGROUND->	352	15.6	2.98	45.1	436	ND	.0038*
33-86		DRY						
39-86	MAXIMUM FREQUENCY	452 12/12	41.0 12/12	7.2 12/12	66.3 11/12		NR	0/3
41-86	MAXIMUM FREQUENCY	1806 10/10	947 10/10	13.6 9/10	78.5 10/10		NR	0/3
42-86	MAXIMUM FREQUENCY	526 10/11	57.0 11/11	7.2 10/11	70.0 1/11		NR	0/3
43-86	MAXIMUM FREQUENCY	409 2/3	51.0 3/3	7.9 3/3	•		NA	0/3
10-87		DRY	., .	-,-				-,-
15-87	MAXIMUM FREQUENCY	487 3/3	58.8 3/3	9.1 3/3			NR	
17-87	MAXIMUM FREQUENCY	466 7/7	275 7/7		83.0 3/7		NR .	0/0
19-87		DRY						
24-87		DRY						
26-87		DRY					•	
27-87	MAXIMUM FREQUENCY	439 4/4	34.6 4/4	9.92 3/3	77.3 4/4		NR	NR
32-87	MAXIMUM FREQUENCY	630 6/6	40.7 6/6	15.5 6/6	113 6/6		NR	NR
33-87		DRY	•		•			
35-87		DRY						

*Max. of background conc. range NSS - Insufficient Sample for Analysis ND - Not Detected NR - Not Reported U - Detection Limit J - Present below detection limit MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-13B

VALLEY FILL ALLUVIUM MAXIMA AND FREQUENCY OF INORGANIC CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		T.D.S.	Chloride	Nitrate/ Nitrite	Sulfate	Bicarbonate	Carbonate	Cyanide
	BACKGROUND->	947	40.3	0.69*	150	719	ND	ND
35-86	MAX IMUM FREQUENCY	1011 9/11	108 11/11		3/11			
36-86		DRY						
37-86		DRY						
64-86	MAXIMUM FREQUENCY		54.1 3/4	1.28 2/4	180 3/4		0/1	0/1
65-86	MAXIMUM FREQUENCY		64.0 5/5		190 1/5			0/4
66-86	MAXIMUM FREQUENCY		51 3/7				0/1	0/3
21-87		DRY						

^{*}Max. of background conc. range - NSS - Insufficient Sample for Analysis - ND - Not Detected - NR - Not Reported - U - Detection Limit - J - Present below detection limit - MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling - FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-13C

COLLUVIUM MAXIMA AND FREQUENCY OF INORGANIC CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		T.D.S.	Chloride	Nitrate/ Nitrite	Sulfate	Bicarbonate	Carbonate	Cyanide
63-86	BACKGROUND->	520°	20*	0.18*	86*	470*	ND	ND
67-86	MAXIMUM FREQUENCY	564 3/3	47.2 3/3	4.9 3/3	110 2/3		NR	0/3
29-87	MAXIMUM FREQUENCY	3219 7/7	819 7/7	.96 6/7	1157 7/7		NR	NR
44-87		DRY						

^{*}Max. of background conc. range NSS - Insufficient Sample for Analysis ND - Not Detected NR - Not Reported U - Detection Limit J - Present below detection limit MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-13D

WEATHERED CLAYSTONE MAXIMA AND FREQUENCY OF INORGANIC CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		T.D.S.	Chloride	Nitrate/ Nitrite	Sulfate	Bicarbonate	Carbonate	Cyanide
					 			
:-::	BACKGROUND->	320*	11.	0.58*	44*	400	ND	.0036*
1-71	MAXIMUM FREQUENCY	329 2/14	21.5 14/14	7.3 14/14				0/5
2-71	MAXIMUM FREQUENCY	1627 9/9	573 9/9	5.4 9/9			NR	0/5
1-74	MAXIMUM FREQUENCY	490 9/9	30.5 9/9	9.8 9/9			NR	0/3
3-74	MAXIMUM FREQUENCY	490 7/7	122 6/7	9.6 7/7			NR	0/3

^{*}Max. of background conc. range NSS - Insufficient Sample for Analysis ND - Not Detected NR - Not Reported U - Detection Limit J - Present below detection limit MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-13E

WEATHERED SANDSTONE MAXIMA AND FREQUENCY OF INORGANIC CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		T.D.S.	Chloride	Nitrate/ Nitrite	Sulfate	Bicarbonate	Carbonate	Cyanide ———
•••••	BACKGROUND->	170*	15*	1.6*	16*	140*	ND	ND
62-86	MAXIMUM FREQUENCY	328 12/12	102 12/12	7.41 11/12	90 12/12	178 6/12	9 3/3	0/5
9-87	MAXIMUM FREQUENCY	311 8/8		2.96 8/8	56.8 8/8	198 8/8	NR	NR
11-87	MAXIMUM FREQUENCY	654 3/3	92.4 3/3	2.25 3/3	108 3/3	368 3/3	NR	0/2
12-87	MAXIMUM FREQUENCY	641 3/3	57 3/3	1.6 3/3	203 3/3	354 3/3	NR	NR
14-87	MAXIMUM FREQUENCY	661 9/9	32.1 3/9	1.83 9/9	48.8 9/9	530 1/9	505 7/7	0/1
23-87	MAXIMUM FREQUENCY	459 8/8	65.8 8/8	2.98 8/8	70.4 8/8	261 8/8	NR	0/1
25-87	MAXIMUM - FREQUENCY	496 9/9	41.1 9/9	8.02 9/9	52 9/9	281 9/9	NR	NR
36-87	MAX I MUM FREQUENCY	486 7/7	218 7/7	B.06 7/7	43.5 7/7	281 6/7	NR	NR

TABLE 2-13F

UNWEATHERED SANDSTONE MAXIMA AND FREQUENCY OF INORGANIC CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		T.D.S.	Chloride	Nitrate/ Nitrite	Sulfate	Bicarbonate	Carbonate	Cyanide
34-86	BACKGROUND->	1761	607	0.61	950	412	49	ND
40-86	FREQUENCY MAXIMUM	1813 4/11	19.9	6.62 5/5	1084 4/11		NR NR	0/4
16-87	FREQUENCY MAXIMUM FREQUENCY		1/6	5/5 2.02 4/8			5.5 1/1	0/2
18-87	MAXIMUM FREQUENCY	0/1	0/1	0/1	0/1	0/1	NR	NR
20-87	MAXIMUM FREQUENCY	0/1	0/1	0/1	0/1	0/1	35.9 1/1	NR
28-87	MAXIMUM FREQUENCY						3.14 1/1	NR
30-87	MAXIMUM FREQUENCY MAXIMUM						NR	NR NR
31-87	FREQUENCY MAXIMUM FREQUENCY			3.55 1/7			21.1 · 6/6	
34-87	MAXIMUM FREQUENCY						-,-	
45-87	MAXIMUM FREQUENCY						0/1	0/1

^{*}Max. of background conc. range NSS - Insufficient Sample for Analysis ND - Not Detected NR - Not Reported U - Detection Limit J - Present below detection limit MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-14A

ROCKY FLATS ALLUVIUM MAXIMA AND FREQUENCY OF DISSOLVED METAL CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		<u></u>	Sb	\\ -	Ba —	Be —	Cd —	Ca —	Cr —	Cu —	Fe —	Pb —	Li —	Hg —	Mg 	Mn —	Мо —	Ni —	K —	Se —	Ag —	Na —	sr \	<u>-</u>	Zn —
	BACKGROUND->	ND	ND	ND	ND	ND	ND	85	ND	ND	. 266	• ND	ND	ND	5.79*	. 365	.0136	.0432	• 7.73	J* ND	ND	13.4	.159* N	Ď	. 141-
39-86	MAX IMUM FREQUENCY	.085 6/16	• ••••	••••	.28 13/14			120	3			• ••••	0.1U 0/3		13.4 14/16	1/16						18.9 14/16	.55 14/16		
33-86		DRY	1987-	1989									•		•	•						·	•		
41-86	MAX IMUM FREQUENCY	.07 4/10	.04 1/10		.23 8/10	.004J 2/9	.001 1/9	130 8/10	.012 2/10	.02 4/10	.58 1/10		0.1U 0/2		17.8 9/10	.85 1/10		.075 2/10	8.2 1/10)	.03 1/10	51.3 9/10	.67 9/10 1)37 /4	
42-86	MAXIMUM FREQUENCY	2.6 5/14	.04 1/14		.33 13/14	ı		165 13/14	.02 1 1/14	.06 4/14	2.1 9/14	.013 2/14	0.1U 0/2	0.013 2/11	14.9 13/14	.61 9/14		.10 4/14	•		.13 1/14	18.1 13/14	.57 12/14 1)39 /8	
43-86	MAXIMUM FREQUENCY	.04 1/3			. 16 3/3			95 2/3							10.5 3/3		.024 1/3				·	14.2 2/3	.43		
10-87		DRY	1987-	1989									•												
15-87	MAXIMUM FREQUENCY	.05 3/6	.019 1/5		. 19 5/6			134 6/6	.038 1/6	.01 3/6	.05 2/6		. 1U 0/4		11.1 6/6						.04 1/6		. 49 6/6		
17-87	MAXIMUM FREQUENCY	.07 4/9			0.16 5/9			117 9/9	.01 1/9	.42 7/9	.05 5/9		.1U 0/3		13.3 9/9	1.27 1/9		.69 9/9				, 28.5 9/9	.60		2.56 3/7
19-87		DAY	1987-	1989														•				•	•		
24-87		DRY	1987-	1989																					
26-87		DRY	1987-	1989																					
27-87	MAXIMUM FREQUENCY	.05 2/5			. 12 3/5			95 4/5		.008 2/5			NR		15.8 5/5	.009 1/5					.01 1/5	30.1 5/5	.60 5/5		
32-87	MAXIMUM FREQUENCY	.04 3/6			.20 4/5			129 4/5	.04 1/5	.22 3/6			. 1U 0/1		19.4 5/6	.62 2/6		. 37 3/6			-	31.8	.63 5/6		. 98 4/6
33-87		DRY	1987-	1989											•	•		•				•	, -		• -
35-87		DRY	1987-	1989																					

TABLE 2-14B

VALLEY FILL ALLUVIUM MAXIMA AND FREQUENCY OF DISSOLVED METAL CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		Al	Sb	As	Ba	Cđ	Ca	Cr	Cu	Fe	Pb	Li	Mg	Mn	Мо	Ni	K	Se	Ag	Na	Sr	v	Zn
		—	_		_					_								_			_		
	BACKGROUND->	ND	ND	ND	ND	ND	138	ND	ND	.94*	ND	.28*	26.6	.69*	ND	ND	ND	.011*	ND	88	ND	ND	.021*
35-86	MAXIMUM FREQUENCY	.11 4/12	.05 2/12	.004J 6/11	. 12 8/12		170 9/12	.027 1/12	.01 6/12				68 12/12	4.37 11/12			2.3 6/12			210	.96 12/12		.04 7/12
36-86		DRY																					
37-86		DRY																					
64-86	MAXIMUM FREQUENCY	.043 2/5			.11 4/5				.034 3/5			. 1U 0/3		.78 1/5	.027 2/5	.049 2/5	2.4 3/5			167 3/5	.70 4/5		
65-86	MAXIMUM FREQUENCY	.24 4/10	.078 2/10		.24 5/10	.001 1/6			.02 2/10		.024 2/6	. 1U 0/4				.053 1/10	2.7 5/10				0.78 7/10		.099 6/10
66-86	MAXIMUM FREQUENCY	.053 3/7			.11 4/7				.007 1/7		.04 2/7	. 1U 0/5			. 10 3/7	1.7					. 37 5/7		.072 5/7
21-87		NSS																					

NSS = Insufficient Sample for Analysis ND = Not Detected NR = Not Reported U = Detection Limit J = Present below detection limit
Hax. of background conc. range MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

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COLLUVIUM MAXIMA AND FREQUENCY OF DISSOLVED METAL CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well	Al	Sb	As	Ba	Cd	Ca	Cr	Cu	Fe	Pb	Li	Mg	Mn	Mo	Ni	K	Se	Ag	Na	Sr	V	Zn
	_		-		—	_		_	_	_	_	_			_				_	_		
BACKGROUND->	ND	ND	ND	ND	ND	77*	ND	ND	ND	ND	. 172*	15.3	. 088*	ND	ND	ND	ND	ND	98.7*	ND	ND	ND
63-86	DRY																					
67-86 MAXIMUM FREQUENCY	.04 2/5			.25 5/5		89 3/5		.018 2/5		.022 1/5	NR	38.1 5/5	.17 2/5					.016 1/5		1.2 5/5	.036 1/5	.068 2/5
29-87 Maximum Frequency	.09 4/8	. 12 3/7		.07 5/8		358 7/7	.03 3/8	.84 ' 5/8				136 7/8	. 39 2/8	. uB 3/8	1.41 7/8	5.2 4/6	. 45 5/5		405 7/8	4.95 7/8		2.77 7/8
44-87	DRY																					

: - Insufficient Sample for Analysis ND = Not Detected NR + Not Reported U = Detection Limit J = Present below detection limit
'Max. of background conc. range MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-14D

WEATHERED CLAYSTONE MAXIMA AND FREQUENCY OF DISSOLVED METAL CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		<u>~1</u>	Sb 	As —	Ba —	Cd —	Ca —	Cr —	Cu —	Fe —	Pb —	Li —	Мд —	Mn —	Mo —	Ni —	<u>K</u>	Se —	Ag —	Na —	Sr —	<u>v</u>	2 n
	BACKGROUND->	ND	ND	ND	ND	ND	73.4*	ND	ND	, ND	ND	.031*	45.3*	.015*	ND	ND	ND	ND	ND	36.9*	ND	ИĎ	.107*
1-71	MAXIMUM FREQUENCY	.06 4/15	.036 3/15		.30 13/15		87 7/15		.016 2/15	1.23	.02 1/15	.1 U 0/3		.16 14/15	•••••	.05 1/15	2.6 9/15	.015 1/15			.58 14/15		
2-71	MAX I MUM FREQUENCY	.064 4/11	.071 1/11		. 16 10/11		201 6/11	.029 3/11	.02 2/11	.92 9/11	.019 1/11	.07J 0/3		.80 11/11	. 192 1/11	.05 2/11	2.7 6/10	.04 10/10	.02 1/11	259 11/11	1.61 11/11		
1-74	MAXIMUM FREQUENCY	.066 4/11			. 18 8/11		116 11/11		.015 3/11	.06 6/11	.008 2/11	.1 U 0/3		.34 3/11			3.8 6/11				.83 11/11		
3-74	MAX I MUM FREQUENCY	. 39 4/8			.29 1/8		135 6/8	. 12 1/8	.02 5/8	. 35 6/8	.007 1/8	.1 U 0/2		.063 1/11		.045 1/11	1.0 6/8				. 40 8/8		. 36 5/8

NSS = Insufficient Sample for Analysis ND = Not Detected NR = Not Reported U = Detection Limit J = Present below detection limit
Max. of background conc. range MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-14E

WEATHERED SANDSTONE MAXIMA AND FREQUENCY OF DISSOLVED METAL CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well	_	<u> </u>	Sb —	As —	Ba —	Cd —	Ca —	Cr —	Cu —	Fe —	Pb	Li —	М <u>д</u>	Mn —	Мо —	Ni —	<u>к</u>	Se —	Ag —	Na 	T1	Sr —	<u>v</u>	Zn
	BACKGROUND->	ND	ND	ND	ND	ND	65.7*	.012	ND	ND	ND	.0106*	9.41	.292*	.015*	ND	ND	ND	ND	25.6*	ND	ND	ND	ND
62-86	MAXIMUM FREQUENCY	4.75 12/15	.058 1/15	.007 1/15	.13 6/15	.009A 1/12		.045 12/15	.017 3/15	2.9 9/15	.021 2/15	.04 1/5	12.4 9/15			.10 4/15	44.5 14/15	.07 13/15		62.2 15/15		.52 15/15		.092 5/15
9-87	MAXIMUM FREQUENCY	.05 3/9			. 12 5/9		103 8/9	.021 2/9	.024 2/9	.073 4/9		.1 U 0/3					5/9	.004 1/9				. 36 8/9		.04 5/9
11-87	MAXIMUM FREQUENCY				.13 2/2		117 2/2					.07 1/2	29.0 2/2	. 39 2/2		. 26 1/2	7.9 2/2	.02 2/2		51.3 2/2		.96 2/2		
12-67	MAXIMUM FREQUENCY	.085 3/4			.084			.056 1/4	.01 3/4	.21 4/4		.13 2/3				.12	3.5 4/4					.27 4/4		.05 2/4
14-87	MAX IMUM FREQUENCY	1.20 6/12	.029 1/12		.93 6/12		408 2/12	.04 7/12	.01 5/12	.06 4/12		. 10 1/6	11.8 1/12				31 7/12	.014 7/12		96.2 10/12		7.7 8/12	.092 3/12	.03 3/12
23-87	MAXIMUM FREQUENCY	.17 3/10			. 19 6/10		130 10/10	.068 1/10	.015 1/10	. 19 5/10		o/3	14.4 10/10			.056 1/10	4.6 5/10				0.01 1/7	.62 10/10	.028 1/-10	.08 5/10
25-87	MAXIMUM FREQUENCY	2.68 4/9			;17 7/9		130 9/9	.07 2/9	.013 1/9	4.35 6/9			-	.71 2/9	.023 1/9		3.9 4/9					. 38 9/9	.0401 1/9	•
36-87	MAXIMUM FREQUENCY	.068 3/7			;22 7/7		123 7/7	.02 2/7	.01 2/7	.03 5/7		.1 U	10.4 3/7	.35 7/7	•	.05 2/7	1.85 5/7					43 7/7	٠	.037 4/7

NSS = Insufficient Semple for Analysis ND = Not Detected NR = Not Reported U = Detection Limit J = Present below detection limit A = Data accepted with qualifications
"Max. of background conc. range MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-14F

UNWEATHERED SANDSTONE MAXIMA AND FREQUENCY OF DISSOLVED METAL CONCENTRATIONS (MG/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		Al	Sb	As -	Ba —	Cd	Ca	Cr	Cu	Pe —	Pb	Li —	Mg —	Mn	Mo	Ni —	<u>K</u>	Se —	Ag —	Na —	Sr —	v	Zn
	BACKGROUND->	. 327*	ND ND	.019*	ND	ND	64.6	ND	ND	ND	ND	ND	ND	.018•	.112*	ND	21.9*	.041	ND	599	.45*	ND	. 56
34-86	MAXIMUM FREQUENCY		.11 2/11		.09 9/11	• ••••	242 11/11	.017	.012 4/11	2.18 11/11		.2 1/2	92 11/11	.14					•		3.1		
40-86	HAXIMUM FREQUENCY	.47 2/5			.073 4/4		153 4/4	.027 1/4	.01 3/5	.24 4/5		.04 J 0/3	31.3 5/5	.54 4/5	.10 4/5	.05 3/5			.03 1/4		1.49		
16-87	MAXIMUM FREQUENCY	,			.08 6/8			.028 3/8	.011 2/8	.14 5/8		.05 J 0/3	5.97 7/8		.037 5/8						.35 7/8		
18-87	MAXIMUM FREQUENCY	.09 1/1			:11 1/1				.04 1/1	.06 1/1			1.1	.12 1/1	.029 1/1	.066 1/1			.01 1/1		i/1		
20-87	MAXIMUM FREQUENCY	.26 1/1		.007 1/1	.03 1/1				.007 1/1	.034 1/1		.1 U	.034 1/1		.057 1/1						.44 1/1	.038 1/1	
22-87	MAXIHUM FREQUENCY	.05 4/6			.06 4/6			.012 2/6	.018 2/6	.04 4/6		ċ1₁ ^U	17.5 6/6	.07 6/6	.08 5/6						.89 6/6	.10 1/3	
28-87	MAXIMUM FREQUENCY	i/3			.09 2/3				.05 1/3	. 18 2/3		ن ۱۵	3.1 2/3	.03 1/2	.13 2/3						.24 2/3		
30-87	MAXIMUM FREQUENCY	.08 5/9		.04 3/9	.10 7/9					.07 7/9	.009	.1 U	3.42 7/9		.025 1/9			i/9			. 33 8/9		
31-87	MAXIMUM FREQUENCY	. 28 5/7		.019 3/6	.05 4/6				.014 3/7	. 17 5/7		.1 U	1.02 5/7		.05 4/6				·		.23 6/7		
34-87	MAKIMUM FREQUENCY	.12 2/4		.007 1/4	.05 3/4			.012 3/4	.013 2/4	.97 3/4		1/1	64 3/4	.15 3/4	.036 3/3						2.60 3/4		
45-87	MAXIMUM FREQUENCY	.13 4/8			.17 6/8	.006 1/8			.01 3/8	. 12 5/8		.06 J 0/3	13.3 8/8	.40 8/8	.065 4/4	.039 1/8					. 49 7/8		

. of background conc. range MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

- Insufficient Sample for Analysis ND - Not Detected NR - Not Reported U - Detection Limit J - Present below detection limit

TABLE 2-15A

ROCKY FLATS ALLUVIUM MAXIMA AND FREQUENCY OF DISSOLVED RADIOCHEMISTRY CONCENTRATIONS (PCI/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		Alpha	Beta ——	U233,U234	U235	U238 ——	Pu239, Pu240	Am 241	Tritium
•	BACKGROUND->	12	15	1.6	0	1.2	.01	o	309
33-86		DRY							
39-86	MAXIMUM FREQUENCY	26 2/9	32 3/9	2.9 7/7	.17 5/7	1.9 7/7			
41-86	MAXIMUM FREQUENCY	19 1/6	85 4/6	3.9 5/5	. 18 5/5	2.4 5/5			•
42-86	MAXIMUM FREQUENCY	215 1/7	144 1/7	2.8 1/6	.08 1/6	2.6 1/6	0.18 1/6	•	560 2/6
43-86	MAXIMUM FREQUENCY								
10-87		DRY							•
15-87	MAXIMUM FREQUENCY	46 3/4		2.9 3/4		2.74	0.52 1/4	0.83 1/4	
17-87	MAXIMUM FREQUENCY	18 1/6	18 1/6	5.2 3/5	.25 4/4	4.1 3/4			
19-87		DRY			•				
24-87		DRY							
26-87		DRY							
27-87	MAXIMUM FREQUENCY			4.6 2/2	. 12 2/2	3.2 2/2	•		
32-87	MAXIMUM FREQUENCY	78 3/5	61 1/5	4.6 4/4	.28 4/4	2.8 4/4	·	0.1 1/4	
33-87		DRY	-	•	•	-		•	
35-87		DRY					*		

*Max. of background conc. range NSS - Insufficient Sample for Analysis ND - Not Detected NR - Not Reported U - Detection Limit J - Present below detection limit MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-15B

VALLEY FILL ALLUVIUM MAXIMA AND FREQUENCY OF DISSOLVED RADIOCHEMISTRY CONCENTRATIONS (PCI/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Woll		Alpha	Beta	U233,U234	U235	U238	Pu239,Pu240	Am241
			- · · · · ·					
	BACKGROUND->	14	19	6.5	0.2	5.1	.01	0.01
35-86	MAXIMUM FREQUENCY							
36-86		DRY						
37-86		DRY						
64-86	MAXIMUM FREQUENCY							
65-86	MAXIMUM FREQUENCY				.4 2/3			
66-86	MAXIMUM FREQUENCY							
21-87		DRY						

*Max. of background conc. range NSS - Insufficient Sample for Analysis ND - Not Detected NR - Not Reported U - Detection Limit J - Present below detection limit MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-15C

COLLUVIUM MAXIMA AND FREQUENCY OF DISSOLVED RADIOCHEMISTRY CONCENTRATIONS (PCI/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well	Alpha	Beta	U233,U234	U235	U238	Pu239, Pu240	Am241
							
BACKGROUND->	27*	12*	11*	0.3*	7.7*	0*	0*
63-86	DRY				******	******	
67-86							
MAXIMUM FREQUENCY		49 1/1	1.6 1/1		2.5 1/1		
29-87		-,-	-,-		-,-		
MAXIMUM FREQUENCY	32 1/6	33 1/6	15 3/3	.73 3/3	11 3/3		
44-87	DRY						

TABLE 2-15D

WEATHERED CLAYSTONE MAXIMA AND FREQUENCY OF DISSOLVED RADIOCHEMISTRY CONCENTRATIONS (PCI/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		Alpha	Beta	U233,U234	U235	U238	Pu239, Pu240	Am241	Sr89, Sr90
									
	BACKGROUND->	12*	7•	5.8*	.2*	3.2	.03	0	0.1
1-71	MAXIMUM FREQUENCY		14 2/6	6.3 1/6	; 5 ; 76	4.1 1/6			
2-71	MAXIMUM FREQUENCY	37 3/4	25 1/4	25 6/6	.9 5/5	18 6/6			· .
1-74	MAXIMUM FREQUENCY								5.0 1/2
3-74	MAXIMUM FREQUENCY	250 1/5	327 3/6	2.4 1/5					

[&]quot;Mex. of background conc. range NSS - Insufficient Sample for Analysis ND - Not Detected NR - Not Reported U - Detection Limit J - Present below detection limit MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

TABLE 2-15E

WEATHERED SANDSTONE MAXIMA AND FREQUENCY OF DISSOLVED RADIOCHEMISTRY CONCENTRATIONS (PCI/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

Well		Alpha	Beta ———	U233,U234	U235	U238	Pu239, Pu240	Am241
	BACKGROUND->	7•	2•	1.1*	0*	0.6*	.01*	.01*
62-86	MAXIMUM FREQUENCY	27 1/5	24 1/5	4.3 4/5	.3 5/6	9.5 5/6	.6 3/6	.01-
9-87	MAXIMUM FREQUENCY		3.3 1/7		.05 2/3	.67 3/3		
11-87	MAXIMUM FREQUENCY	28 1/2		9.6 1/2		6.5 2/2	.20+/07 1/2	.06+/05 1/2
12-87	MAXIMUM FREQUENCY	121 4/4	57 4/4	34 3/3	1.7 3/3	28 3/3		
14-87	MAXIMUM FREQUENCY	17 3/7	19 5/7	6.7 2/2	.05 1/1	4.3		
23-87	MAXIMUM FREQUENCY	39 2/7	5.9 3/7	6.7 5/5	. 14 5/5	4.3 5/5		
25-87	MAXIMUM FREQUENCY	19 1/8	7.4 1/8	3.2 6/6	.09 1/5	1.8 5/5		
36-87	MAX IMUM FREQUENCY	17 2/6	23 3/6	2.3 3/4	.10 2/4	1.4 3/4		

TABLE 2-15F

UNWEATHERED SANDSTONE MAXIMA AND PREQUENCY OF DISSOLVED RADIOCHEMISTRY CONCENTRATIONS (PCI/L) EXCEEDING BACKGROUND IN GROUND WATER (1987-1989)

	Alpha	Beta ———	U233,U234	U235	U238	Pu239, Pu240	Am 241
MBER	ALPHA	BETA	U233,U234	U235	U238	PU239, PU240	AM241
BACKGROUND->	13*	15*	13	0.1*	3.4	0	0.02
MAXIMUM FREQUENCY				. 18 1/7			.11+/05 1/7
MAXIMUM FREQUENCY	106 3/3	207 2/3		.45 3/3	3.9 3/3		
MAX IMUM FREQUENCY	48 3/8	16 1/8		.21 2/4			
MAXIMUM FREQUENCY		24 1/1					
MAXIMUM FREQUENCY		37 1/1	NR	NR	NR		
MAXIMUM FREQUENCY	22 1/6			. 18 2/5			.11+/08 1/5
MAXIMUM FREQUENCY							
MAXIMUM FREQUENCY	33 1/7						. 17+/ 12 1/6
MAXIMUM FREQUENCY	36 1/6						
MAXIMUM FREQUENCY		16 1/4		.21 1/4			
MAXIMUM FREQUENCY	32 2/5	113 5/5		.12 1/5			
	BACKGROUND-> MAXIMUM FREQUENCY MBER ALPHA BACKGROUND-> 13* MAXIMUM FREQUENCY MAXIMUM 106 FREQUENCY 3/3 MAXIMUM 48 FREQUENCY 3/8 MAXIMUM FREQUENCY MAXIMUM FREQUENCY 1/6 MAXIMUM 7 MAXIMUM 7 MAXIMUM 33 FREQUENCY 1/7 MAXIMUM 36 FREQUENCY 1/6 MAXIMUM 36 FREQUENCY 1/6 MAXIMUM 36 FREQUENCY 1/6 MAXIMUM 36 FREQUENCY 1/6	### BETA #### BACKGROUND-> 13° 15° ###################################	MBER ALPHA BETA U233,U234 BACKGROUND-> 13° 15° 13 MAXIMUM FREQUENCY MAXIMUM 106 207 FREQUENCY 3/3 2/3 MAXIMUM 48 16 FREQUENCY 3/8 1/8 MAXIMUM 24 1/1 MAXIMUM 37 FREQUENCY 1/1 MAXIMUM 37 FREQUENCY 1/6 MAXIMUM 36 FREQUENCY 1/6 MAXIMUM 36 FREQUENCY 1/6 MAXIMUM 16 FREQUENCY 1/6 MAXIMUM 16 FREQUENCY 1/6	### ALPHA BETA U233,U234 U235 ###################################	### BETA U233,U234 U235 U238 ###################################	BACKGROUND-> 13* 15* 13 0.1* 3.4 0 MAXIMAM FREQUENCY 3/3 2/3 3/3 3/3 MAXIMAM 48 16 2/4 MAXIMAM 24 1/8 2/4 MAXIMAM 24 1/1 MAXIMAM 24 1/1 MAXIMAM 27 1/1 MAXIMAM 37 NR NR NR MAXIMAM 78 2/5 MAXIMAM 33 78 1/6 MAXIMAM 36 78 6 1/6 MAXIMAM 36 1/6 MAXIMAM 16 1/4	

*Max. of background conc. range NSS - Insufficient Sample for Analysis ND - Not Detected NR - Not Reported U - Detection Limit J - Present below detection limit MAXIMUM - Maximum conc. above background reported over course of Phase I RI sampling FREQUENCY - no. of values above background / no. of samples analyzed.

this location would cause accumulation of salts in the local soils, forming a saline reserve which would chemically alter the local ground water. Other upslope, non-saline ground-water sources could have the same

effect.

In general, this evaporative concentration effect may explain the elevated TDS southeast of the 903 Pad where

surface seeps are abundant, and evaporative mineral deposits in the soils are likely. This is discussed further

in Section 2.3.8.

<u>Metals</u>

In the second quarter 1989 data for all the wells at the 903 Pad, Mound and East Trenches Areas, all of the

dissolved metals except beryllium, cadmium, cobalt (Co), cesium, and thallium (TI) exceeded background, and

all the wells had some subset of these metals occurring above background concentrations (Table 2-12B).

When multiple samplings are accounted for (Table 2-14A through F), it becomes more apparent that only a

subset of the analytes repeatedly exceed background and/or exceed background by a wide margin.

Barium and strontium (Sr) exceeded background more consistently than all of the other trace metals, with

maximum concentrations of 0.93 mg/ ℓ and 7.7 mg/ ℓ , respectively (both in well 14-87)(Table 2-14E). The

relatively uniform concentrations of barium (0.1-0.2 mg/ ℓ) may indicate that the solubility of barium sulfate is controlling the barium concentration. Equilibrium control of barium is typical for natural waters (Hem, 1985).

and the observed barium and sulfate concentrations are consistent with the barium sulfate solubility product

of 10⁻¹⁰ (Sillen and Martell, 1964). Similarly, strontium may be controlled by the solubility of a strontium sulfate

mineral in waters where strontium is sufficiently high (Hem. 1985).

Several other trace metals less consistently (with respect to time) and less ubiquitously occurred above

background. These include copper, iron, molybdenum, nickel, selenium, vanadium, and zinc. In many

instances these elements occur at low concentrations near background so that geochemical phenomena, e.g.

adsorption on oxides, ion exchange, and/or biological activity, may control their concentration more so than

contaminant releases from sources (if they exist). There are no absolute criteria with which to define such

thresholds, but the following discussion focuses on wells which repeatedly exhibit unusually high metal

concentrations and/or concentrations consistently above background. Table 2-14A through F provides the

maximum metal concentrations and their frequency of occurrence above background.

In the 903 Pad Area, well 29-87 has generally consistent above-background concentrations of copper, nickel.

zinc, and selenium. Well 62-86 is noteworthy because of consistently elevated chromium (albeit low

concentrations), and well 2-71 is noted for consistently elevated but low concentrations of selenium. In the

Mound Area, well 17-87 has high concentrations of copper, nickel, and zinc. In the East Trenches Area, well

42-86 has high iron and manganese; well 32-87 has high copper, nickel and zinc; and well 3-74 has high iron and zinc. In general, antimony, lead, lithium, silver (Ag), mercury, and cobalt exceeded background

infrequently and by a very small margin in ground water at the 903 Pad, Mound, and East Trenches Areas.

Radionuclides

All three uranium isotopes were above background at the 903 Pad, Mound and East Trenches Areas in the first

quarter of 1989 (Tables 15A through F). Other radionuclides were not present above background in the first

quarter of 1989, but there were seven earlier samples that contained plutonium and/or americium above

background. Results at wells 15-87 and 11-87 were the most elevated (plutonium - 0.522 \pm 0.117 pCi/ ℓ and

 0.199 ± 0.07 pCi/ ℓ , respectively; americium -0.831 ± 0.148 pCi/ ℓ and 0.06 ± 0.05 pCi/ ℓ , respectively).

Several results showed strontium-89, 90 and tritium slightly above background, but these radionuclides were

not reported for most of the samples and detection limits were commonly above background. Cesium-137 was

not reported. The data for these three radionuclides are inadequate to assess contamination.

Several wells within or downgradient of the 903 Pad Area exhibit uranium-238 in excess of background, with

a maximum of 28 ± 2 pCi/£ at well 12-87 (in weathered sandstone). Other wells in the 903 Pad Area, 2-71

(in Rocky Flats Alluvium) and 29-87 (in colluvium), showed elevated uranium concentrations in the majority of

samplings. Uranium concentrations in downgradient wells 62-86 and 14-87 (in weathered sandstone) and in

1-71 (inferred to be in weathered claystone) are lower than at well 12-87, but they are nevertheless above

background. Therefore, the downgradient limit of uranium contamination at the 903 Pad Area is not

established. Wells in unweathered sandstone in the vicinity of the pad (16-87, 30-87, and 45-87) contain slightly

elevated or no uranium-238 above background (maximum concentration was 1.4 pCi/l in well 45-87),

providing inadequate evidence of radionuclide contamination in unweathered bedrock.

Mound Area wells 23-87 (in weathered sandstone) and 17-87 (in Rocky Flats Alluvium) both contained uranium

above-background at numerous samplings, whereas wells 1-74 (in weathered claystone) and 35-86 (in valley

fill alluvium) did not contain above-background uranium. Uranium concentrations are only slightly above

background and therefore do not unequivocally indicate contamination.

Uranium-238 was detected above background in the East Trenches Area in the following wells: 25-87 and

36-87 (in weathered sandstone); and 42-86, 32-87, 41-86, and 39-86 (in Rocky Flats Alluvium). The only well

that did not have above background concentrations of uranium in the vicinity of the East Trenches Areas was

3-74 (in weathered claystone). The areal distribution of uranium in this area is not well characterized.

2.3.4 Surface Water

Twenty-six surface water and surface seep samples in the vicinity of the 903 Pad, Mound, and East Trenches Areas were collected during Phase I RI field activities. The following discussion is based on all available data because many seeps or stream stations are dry during some sampling events. Appendix C contains all available data from 1986 through 1990. These data have been summarized (Appendix D) and compared to ARARs (see Section 7.0 for ARAR identification) because contaminated surface water has been targeted for an IM/IRA. The following discussion makes reference to the tables in Appendix D. Total radiochemical and metals data, although presented in the appendix, are not discussed because an assessment methodology that accounts for varying concentrations of suspended solids is still being developed.

A discussion of surface water chemistry for the 903 Pad, Mound, and East Trenches Areas is also one of ground-water chemistry, as several of the surface water samples collected for this investigation are from seeps that represent the surfacing of ground water or water from depressions in which runoff accumulates. In addition, there is frequent interaction of surface water and ground water in the drainages. The seeps and areas of ponded water are located downslope and southeast of the 903 Pad Area, or downslope and north of the Mound Area and East Trenches Area. Surface water flowing in drainages was sampled at stations on the SID and Woman Creek just upstream of Pond C-2 and at stations upstream of the B-series ponds on South Walnut Creek. The B-series ponds were not sampled for this investigation, as they will be subsequently investigated as part of another operable unit. Surface water locations are shown on Figure 2-11.

2.3.4.1 Surface Water Stations Southeast of 903 Pad Area

There are several seeps downslope to the southeast of the 903 Pad. Surface water stations established at these seeps in the 903 Pad Lip Area are designated SW-50, SW-51, SW-52, SW-55, SW-57, SW-58, and SW-77. Station SW-50 is closest to the 903 Pad, and SW-57 and SW-52 are south of SW-50. SW-51 and SW-58 are located in a ditch along the road east of SW-50; however, only overland flow of seepage from SW-50, SW-52, and SW-57 will also enter the ditch. Water in the ditch passes under the road south of these locations through a culvert. The discharge of the culvert is SW-55. SW-77, another seep located on the east side of the road, is just north of SW-55. It is noted, therefore, that SW-51, SW-58, and SW-55 are physically connected and are likely to receive flow from SW-50, SW-52, and SW-57. Farther downgradient stations include seeps at SW-53, SW-62, SW-63, and SW-64; SW-27, SW-30, SW-54, and SW-70 on the SID; and SW-26, SW-28, and SW-29 on Woman Creek.

Data for seeps in the vicinity of the 903 Pad Lip Site (Table D-1) and farther downgradient at SW-53, SW-63, and SW-64 indicate organic contamination. Contaminants in seeps in the vicinity of the 903 Lip Site include 1,1-DCE, 1,2-dichloroethene (1,2-DCE), CCl₄, TCE, and PCE with concentrations of CCl₄ and TCE exceeding 1,000 μ g/ ℓ . Contaminants 1,2 DCE and TCE are occasionally present at SW-53, low concentrations of CCl₄ and TCE (<20 μ g/ ℓ) occur at SW-63, and low concentrations of TCE occur at SW-64. Methylene chloride also occasionally occurs in these seeps, but at concentrations near the detection limit, and also frequently occurs in the laboratory blanks. Low and very infrequent concentrations of these and other volatiles occur at seep SW-62, as well as stations along the SID and Woman Creek. The data do not provide convincing evidence of impacts at these stations; however, the volatile organic concentrations in the upgradient seeps suggest that a solvent plume within alluvial ground water is migrating to the southeast, which is consistent with the alluvial ground-water flow direction. It is inferred that organic contaminated alluvial ground water approaches the SID and Woman Creek.

With respect to inorganic and dissolved radionuclide contamination, there are somewhat elevated concentrations of TDS, major ions, strontium, zinc, and uranium at most of these stations. Surface water at stations along the SID (SW-70, SW-30, SW-54, and SW-27) all have somewhat elevated uranium concentrations (generally less than 10 pCi/l of total uranium). These concentrations are usually above ARAR (5 pCi/l). Although the 903 Pad Area cannot be ruled out as the source of the uranium, the occurrence of elevated uranium as far upgradient as SW-70 suggests the 881 Hillside Area as a potential source. Alluvial ground water at the 881 Hillside contains above-background levels of uranium.

Seeps in the vicinity of the 903 Pad Lip Site (SW-50 and SW-53), had detectable plutonium and/or americium during one event in 1989. The samples contained substantial suspended solids and were not filtered at the time of collection. Total radiochemistry data do indicate notably higher plutonium and americium concentrations in unfiltered samples than in filtered samples, demonstrating that most of the radionuclides are in a particulate form. Since radionuclide soil contamination is documented in this area, the local soils represent the most direct potential source for seep contamination. However, there were traces of plutonium and americium in a few ground-water samples (highest concentrations at wells 15-87 - 0.522 \pm 0.117 pCi/ ℓ and 0.031 \pm 0.148 pCi/ ℓ , respectively), so ground water is also a potential source of radionuclides in seeps, albeit a less significant one. It is noted that plutonium and americium are essentially insoluble but minute quantities can migrate in colloidal form, and colloidal-size particles can pass through 0.45 micron filters such as those used in the Phase I RI (Puls and Barcelona, 1989).

Regardless of the transport mode, total plutonium concentrations occur above background at station SW-29 on Woman Creek (range: <MDA - 0.315 \pm 0.115 pCi/ ℓ), and dissolved plutonium was just detectable during one sampling event (0.159 \pm 0.142 pCi/ ℓ). Dissolved plutonium was also just detectable at station SW-70 on the SID (0.11 \pm 0.09 pCi/ ℓ); however, the total plutonium concentration was 0.011 \pm 0.057 pCi/ ℓ during this

sampling event, rendering this data questionable. The one datum that exists in the RI data base indicates total plutonium is not above background in Pond C-2 (dissolved radionuclide data are unavailable).

2.3.4.2 Upper South Walnut Creek

At the Mound Area, station SW-60 is a corrugated metal pipe discharging South Walnut Creek flow which originates to the west of SW-56 (not sampled in 1989). Stations SW-56 and SW-101 are in a ditch that appears to be seepage from the base of the hill to the south. The ditch is not part of the main flow of South Walnut Creek, as the creek is routed beneath this area by a corrugated metal pipe that discharges at SW-60. Water in the ditch eventually discharges to South Walnut Creek through a concrete pipe beneath the PA fence. The flow in South Walnut Creek upstream of Pond B-4 is primarily the combined flow from the discharge of these culverts and a seep (SW-59) located at the base of the hill to the south and downstream of the culverts. The seep at SW-59 coincides with the abandoned waste collection pipe (IHSS 142) that joined with the main plant waste discharge line prior to 1983, inside the PA. This combined flow is sampled at SW-61 located at the confluence.

The upper reaches of South Walnut Creek as characterized by data for stations SW-56, SW-59, SW-60, SW-61, and SW-101 contain CCl_4 , PCE, and TCE in concentrations in excess of 200 μ g/ ℓ , with lesser and infrequent concentrations of 1,1-DCE; 1,1-DCA; 1,2-DCE; vinyl chloride; acetone; bromo-dichloromethane; and methylene chloride. These stations also frequently have above ARAR levels of TDS and uranium. The TDS and uranium concentrations are typical of the alluvial ground water in the vicinity of the 903 Pad and Mound Areas. CCl_4 , PCE, TCE, and elevated zinc are also present in the alluvial ground water at the Mound Area.

Stations SW-21 and SW-23 approximately 500 feet farther downstream from the confluence of SW-59, SW-60, and SW-61 do not exhibit the upstream contamination. Although only one datum exists for each station, (August 1986 sampling), $CC1_4$ (9 μ g/ ℓ) was the only volatile organic detected at SW-21, and volatile organics were absent at the further downstream station, SW-23. Although there are no August 1986 data for the upstream stations, the other results suggest the organics have volatilized or were diluted over this reach.

Further surface water (and ground-water) sampling and analysis will be conducted to better define the extent and source of the contamination. However, potential sources outside the Mound Area will be investigated as another operable unit.

2.3.4.3 Seeps at the East Trenches Areas

Of the two seeps at the East Trenches Areas (SW-65 and SW-103), SW-65 has no apparent organic

contamination, and SW-103 has the constant presence of CCI_A at concentrations less than 10 μ g/ ℓ . Dissolved

uranium was also above ARAR at SW-65.

Sampling of both surface water and ground water will continue to better define the extent of surface and

ground-water contamination in this area.

2.3.5 Sediments

Sediment stations have been established along the Woman Creek and the South Walnut Creek drainages. As

shown in Figure 2-12, stations SED-28, SED-29, and SED-25 are located within the SID in the Woman Creek

drainage. SED-30 and SED-31 are seeps on the SID berm near station SED-29. SED-27 and SED-26 are along

Woman Creek just upstream of Pond C-2. Stations SED-11, SED-12, and SED-13 are located along South

Walnut Creek. SED-11 is the most upgradient station, SED-12 is just upstream of Pond B-1, and SED-13 is

just downstream of Pond B-5.

Data discussed herein are for samples collected in 1989 and are presented in Appendix E.

2.3.5.1 Woman Creek Drainage

Chloromethane was present as SED-29 (60 μ g/kg), and CHCl₃ and TCE were reported at SED-31 (18 μ g/kg

and 8 µg/kg, respectively). Several sediment samples contained methylene chloride and acetone at very low

concentrations. These compounds were frequently found in associated blanks. SED-30 contained 220 μ g/kg

acetone at one sampling, but acetone was also present in the blank for this sample and was undetected in two

other sampling events for this station in 1989. Laboratory artifact is suspected for acetone and methylene

chloride results in this area. The only other volatile organic compounds detected in the Woman Creek drainage

sediment samples were TCE (8 μ g/kg) at SED-31 (estimated below detection limits elsewhere) and toluene

(estimated below detection limit) at SED-29 and SED-30.

Of the metals, beryllium, lithium, silver, and tin (Sn) were notably elevated above background in the sediment

of the SID and Woman Creek. Concentrations of silver are greater than five times the upper limit of the

background range (as high as 49.1 mg/kg) at stations SED-29, SED-30, and SED-25. Beryllium was not

detected in the background samples (<1.1 mg/kg) but occurs at concentrations ranging from 3.8 to 15.0

mg/kg in all the sediment samples collected from the SID and Woman Creek. Although tin was not above

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background (<22.8 mg/kg) at SED-27, SED-28, and SED-31, it occurred in a range from 364 to 1,080 mg/kg

at stations SED-25, SED-26, SED-29, and SED-30.

Plutonium was above background at stations SED-25, SED-26, SED-29, and SED-30, ranging in concentration

from 0.3 to 3.3 pCi/g. Contaminated surface soil from the 903 Pad Area, transported by wind, may be the

source of this plutonium.

2.3.5.2 South Walnut Creek Drainage

Limited 1989 data exist for the three sediment stations on South Walnut Creek. There are no data for SED-12

and SED-13, and only volatiles, metals, and other inorganics data exist for SED-11 (Appendix E).

At SED-11, CHCl₃, CCl₄, TCE, PCE, and acetone were present at 10, 52, 17, 39, and 167 μ g/kg, respectively.

This is consistent with the data for SW-61 which indicate that these are surface water contaminants.

As in the Woman Creek drainage, beryllium, lithium, silver, and tin are elevated in the sediments at SED-11.

They occurred at concentrations of 2.5, 7.2, 15.0, and 404 mg/kg, respectively. Zinc, which is a known

contaminant of ground water and surface water in this vicinity, was also notably elevated, occurring at a

concentration of 735 mg/kg (the upper limit of the background tolerance interval is 93 mg/kg).

Sediment samples were taken in October 1989 at stations along South Walnut Creek as well as Woman Creek

and the SID. The resulting data should suffice as confirmatory information regarding the concentrations of

volatile organics, metals, other inorganics, and radionuclides in the sediments and will be presented in the

RFI/RI report. For the Phase II RFI/RI, physical characteristics of the sediments (background and

"downgradient") and the spatial distribution of the metal concentrations will be examined to assess the

adequacy of the background sediment geochemical characterization and, thus, whether metals are

contaminants in the sediments at the 903 Pad, Mound, and East Trenches Areas.

2.3.6 Air

Results of the continuous radionuclide monitoring program characterizing the air pathway at the Plant are

reported in monthly reports and annually in the Annual Environmental Monitoring Reports (e.g., Rockwell

International, 1975 through 1983a, 1984, 1985, 1986b, 1987b, 1989d, and EG&G, 1990f). In addition, the air

pathway was further characterized by the radioecology and airborne pathway study (Rockwell International,

1986f).

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The Radioactive Ambient Air Monitoring Program (RAAMP) consists of 54 high-volume particulate air samplers which operate continuously (Figure 2-12). Twenty-six of the 54 samplers are within or directly adjacent to the Plant security area (on-site samplers) and 14 are located around the property boundary (perimeter samplers). An additional 14 samplers are located in neighboring communities (Figure 2-13).

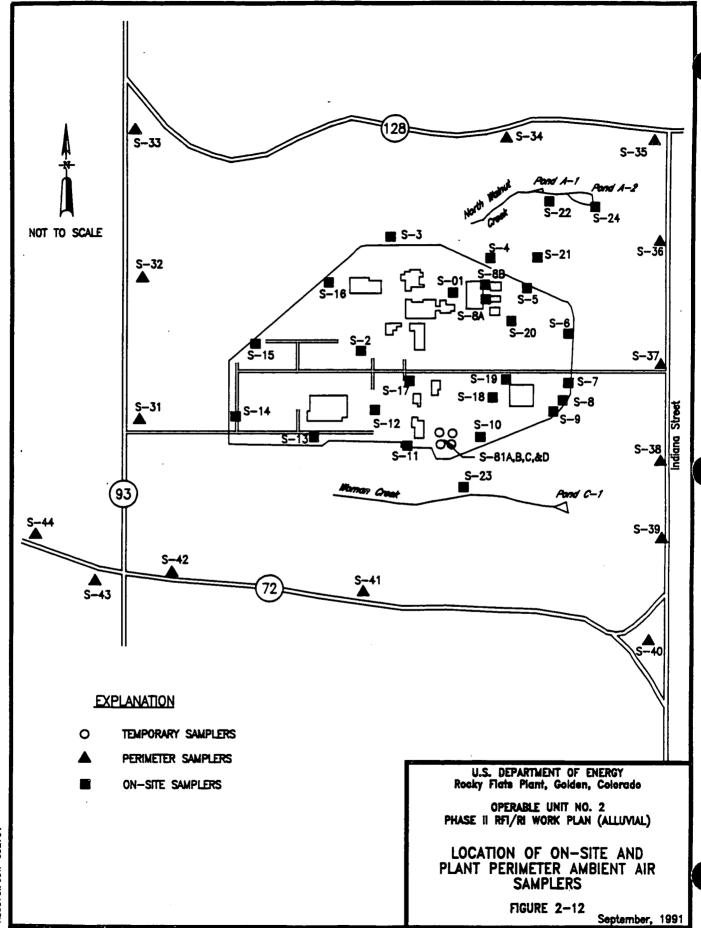
The 903 Pad Area is recognized as one principal source of airborne plutonium contamination at the Plant (Rockwell International, 1975 through 1983a, 1984, 1985, 1986b, 1987b, 1989d, and EG&G, 1990f). Historically, the particulate samplers located immediately east, southeast, and northeast of the 903 Pad, Mound, and East Trenches Areas have shown the highest plutonium concentrations. This finding is corroborated by the results of soil surveys which indicate elevated plutonium concentrations to the east, particularly southeast of the area. However, the RAAMP has found ambient air samples to be well within applicable DOE guidelines for the protection of human health and the environment for all plutonium (Rockwell International, 1989d).

Prior to the Phase I RI activities, personnel trained in industrial hygiene surveyed the 903 Pad Area on March 25, 1987, the Mound Area on April 23, 1987, and the East Trenches Area on April 8, 1987, for the presence of volatile organics in ambient air. The surveys were done with draeger tubes sensitive to PCE and TCE in the parts per million range. These two compounds were chosen since investigations prior to March 1987 had indicated PCE and TCE were the most commonly found contaminants at the 903 Pad, Mound, and East Trenches Areas, and they were also found in higher concentrations than other contaminants. Air sampling was conducted 6 inches above the ground, at numerous point locations throughout the 903 Pad, Mound, and East Trenches Areas. All values were below detection limits.

Ambient air data analyzed for 1987 do not indicate any unusual effects due to Phase I RI field activities at the 903 Pad, Mound, and East Trenches Areas. An analysis of: 1) particulate sampler data from stations near the 903 Pad, Mound, and East Trenches Areas; and 2) real-time volatile organics monitoring, conducted during the summer 1987 field activities, indicates that there were no significant releases of plutonium or volatile organics due to RI field activities. These are verified by the absence of radioactive contamination of either personnel or equipment associated with 903 Pad, Mound, and East Trenches Areas Phase I RI field activities.

High volume air samplers were installed and operated for the duration of the Phase I RI borehole and well drilling activity at the 903 Pad, Mound, and Trench Areas. The samplers were located downwind of each drilling site. At the conclusion of the daily activity, the filters from the air samplers were removed and analyzed for total long lived (TLL) alpha activity. No elevated TLL levels were detected during the Phase I RI.

The RAAMP plutonium data for Plant air sampling stations S-5, S-6, S-7, S-8, S-9, and perimeter air sampling stations S-38, S-39, and S-40 are presented in Table 2-16 for the months of July, August, and September 1987.



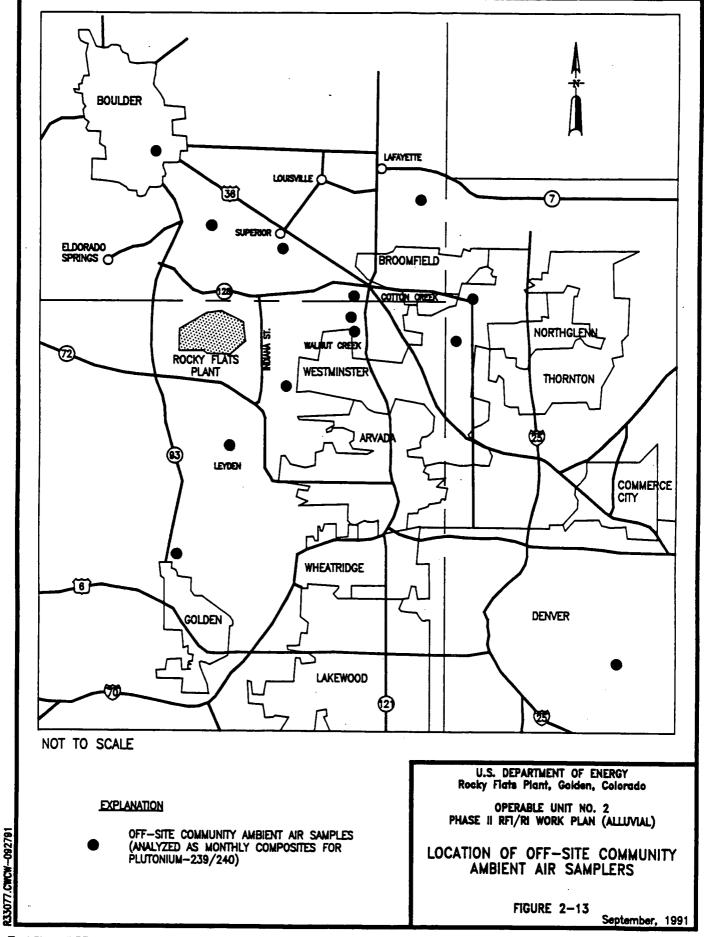


TABLE 2-16

RAAMP AIR SAMPLING SITES PLUTONIUM-239 AND -240 CONCENTRATIONS (pCi/m³) JULY, AUGUST, AND SEPTEMBER 1987

	S-5	S-6	S-7	S-8	S-9	S-38	S-39	S-40
				JULY 1987 DA	<u>.TA</u>			
LCL* Point Estimate UCL**	.000064 .000047 .000029	.00018 .000016 .000005	.003735 .000497 .000190	.002666 .000892 .000696	.001644 .001317 .000362	.000005 .000001 .000015	.000001 0002 .000001	000002 000002 .000007
				AUGUST 1987 [<u>DATA</u>			•
LCL* Point Estimate UCL**	.000076 .000059 .000038	.000134 .000022 .000010	.004170 .000561 .000218	.003018 .000995 .000776	.001859 .001477 .000405	.000008 .000003 .000018	.000003 .000000 .000003	.000000 .000001 .000010
			<u>SI</u>	EPTEMBER 1987	<u> DATA</u>			
LCL* Point Estimate UCL**	.000088 .000071 .000047	.000150 .000028 .000015	.004605 .000625 .000246	.003370 .001098 .000856	.002074 .001637 .000448	.000010 .000005 .000021	.000005 .000002 .000005	.000002 .000004 .000013

LCL* - Lower Confidence Level UCL** - Upper Confidence Level

DOE - Derived Concentration Guide for Plutonium = 0.02 pCi/m³



The perimeter sampling stations in Table 2-16 were selected because they are in predominantly downwind locations from on-site samplers 7,8, and 9. These data cover the period of borehole and well drilling activity at 903 Pad, Mound, and East Trenches Areas. Based on wind rose data for the Plant, these air sampler data have a high probability to indicate releases resulting from drilling and vehicular activity during this period of time.

The monthly averages for plutonium at the perimeter sampling stations (S-38, S-39, S-40) during the site investigation activity are not significantly higher than the historical averages for the same sampling stations. The on-site samplers (S-5, S-6, S-7, S-8, and S-9) have recorded values during site investigation activities below the DOE-derived concentration guide (DCG). The RAAMP samplers show no difference in plutonium concentrations as a result of the drilling activity during the months of July, August, and September 1987.

2.3.7 Biota

The biota at the 903 Pad, Mound and East Trenches Area have been previously studied. A survey was conducted for the Final Environmental Impact Statement, Rocky Flats Plant Site (DOE, 1980), and previous studies were summarized in the Radioecology and Airborne Pathway Data Summary Report (Rockwell International, 1986f). The Radioecology and Airborne Pathway Data Summary Report addresses the plutonium released from the 903 Drum Storage Site and its effects on the immediate environment. Field studies were conducted over several years which compared various biological measurements and pathological data between ecologically similar study areas of widely varying plutonium levels. Soil plutonium concentrations were measured, along with biological measurements such as vegetation community structure and biomass, litter mass, arthropod community structure and biomass, small mammal species occurrence, population density, biomass, reproduction, and physical size of whole carcasses and organs. In addition, pathological examination of small mammals, including x-ray for skeletal sarcomas, microscopy for lung tumors, and necropsy for general pathology and parasite occurrence, were carried out. Results of the studies showed no evidence of ecological impacts attributable to plutonium. Although pathological conditions were found in some rodents, there were no significant pathological differences between control and plutonium-contaminated areas. Other minor differences in biological attributes could not be correlated to plutonium levels.

Aquatic studies, conducted by Colorado State University (CSU), examined phytoplankton, some detritus and small zooplankton uptake of plutonium from the B-series holding ponds. This study showed than an "increase in trophic-level concentration of plutonium did not occur apparently due to a selective mechanism that discriminated against plutonium at this level. This would result in a decreased potential hazard when considering the transfer of plutonium through ingestion routes." (Paine, 1980).

Other aquatic studies revealed that 77 percent of the plutonium associated with crayfish is found in their exoskeleton. Fish flesh and bone from the A- and C-series ponds were never above the minimum detectable

activity for plutonium.

2.3.8 Summary of Contamination

The Phase I RI investigations of environmental media lead to the general conclusions that volatile organic and

radionuclide contamination exists in soils, surface water, ground water, and sediments around several IHSSs.

The distribution and magnitude of the contamination can be better delineated via sampling and analysis

planned for the Phase II investigation.

Plutonium and americium are the principal radionuclide contaminants in the surface soils at the 903 Pad,

Mound, and East Trenches Areas exhibiting elevated concentrations; however, conclusive evidence ruling out

the presence of other radionuclides is not available because of the compositing of soil samples during the

Phase I investigation. The majority of the metals in the soil samples were below background levels. There

were infrequent instances where the metals concentrations exceeded background by a factor of two above

the tolerance intervals. Volatile organic contamination of soils appears to be restricted to the area immediately

beneath and adjacent to the 903 Pad. Volatile organics were also detected at the Trench T-2 Site, the East

Trenches, and the Pallet Burn Site. The Mound Area does not appear to have volatile organic soil

contamination based on the Phase I data.

TCE, PCE, and CCI, are the principal organic contaminants in surface and ground water. Lesser

concentrations of other organic compounds occur at numerous sampling sites throughout OU No. 2.

Plutonium and americium in surface water samples are other apparent indicators of Plant-derived

contamination.

Several metals and other inorganic constituents (including uranium) are also above background in the

environmental media, but the data do not permit unambiguous conclusions with regard to contamination. The

uncertainty results in part from the absence of clear concentration gradients and from the limited knowledge

of the inorganic composition of waste resources OU No. 2; however, there is considerable circumstantial

evidence (listed below) that forms the basis for the hypothesis that evaporative losses at ground-water

discharge zones may be causing accumulation of salts (in soils) and associated local changes in water quality.

Many factors can cause the near-surface, fluctuating water table conditions which are a prerequisite for such

evaporative concentration. Rapid slope changes can be sufficient to induce natural seepage, for example, and

enhanced flow along relatively impermeable rock units can form contact seeps. The presence of caliche in

the vicinity of OU No. 2 indicates that long-term evaporation is a locally significant hydrogeochemical process.

Also, historical changes in the local hydrological regime can cause relatively rapid salt accumulation by

introducing ground water into soils which have not been previously leached. Such "saline seep" formation has been studied extensively (Miller, et al; 1980). Constructed ponds and ditches may have raised the water table and caused dissolution of salts from previously unleached or less leached soils at Rocky Flats. The circumstantial evidence for a local evaporative concentrating process for ground water is as follows:

- Most of the elevated elements are not known constituents of the waste sources in OU No. 2.
- The elevated constituents do not exhibit clear gradients away from known IHSSs, or for that matter, clear horizontal or vertical gradients.
- The variability in inorganic constituent concentrations is typically very small, and almost always within an order of magnitude.
- Some of the major ions do show very pronounced elevation above background, but the highest concentrations of inorganic constituents is in a well which is one of the farthest from the IHSSs (29-87).
- Other parts of the Rocky Flats Plant show similar distributions of major and minor elements and locally very high concentrations of major ions which are not demonstrably derived form IHSSs (wells 5-86 and 6-86). The background characterization may not be adequate because the current data are based on one quarter of sampling, and the well layout was designed without the specific goal of including evaporation-prone zones.
- The wells with the high TDS and major ions commonly also have the most elevated metals and uranium. This raises the possibility that, if the salinity is due to some concentrating process other than waste input, some or all of the minor elements may also occur in elevated concentrations. This is consistent with the observation that the uranium in ground water at the 881 Hillside Area is of natural origin based on uranium-234/uranium-238 ratios. The Plant uses depleted uranium which was found to be present only in some surface soils at the 881 Hillside.

No single feature of the data listed above rules out the possibility that some or all of these inorganic constituents do represent contamination. However, when viewed in aggregate, the observations show that it is plausible, perhaps probable, that these elevated inorganic constituents do not reflect contamination. The conceptual model that local concentrations are due to evaporation of shallow ground water generates several hypothesis which will be tested in part with existing data, and tested more thoroughly with data from the OU No. 2 Phase II activities and the ongoing background characterization.

2.4 SITE CONCEPTUAL MODEL

A site conceptual model was developed based on site physical characteristics and the nature and extent of contamination discussed in Sections 2.1 through 2.3. This model is intended to summarize known and suspected sources of contamination, types of contamination, affected media, contaminant migration pathways, and environmental receptors. It will be used to assist in identifying sampling needs and potential remedial alternatives. The site conceptual model is depicted in Figure 2-14.

2.4.1 Contamination Sources and Types

Sources of contamination at the 903 Pad, Mound, and East Trenches Areas include radionuclide-contaminated

surface soils (originating at the 903 Pad Area), and subsurface contaminated soil and buried wastes. Plutonium

and americium are the principal contaminants of the surface soils. Volatile organics (principally TCE, PCE, and

CCI₄) are the most abundant contaminants of subsurface soils. These contaminants originated from historical

waste spills and buried wastes. The buried wastes are also likely to contain plutonium, americium, and

depleted uranium, although the available data do not show clear evidence of migration of the constituents into

surrounding subsurface soils.

The three principal volatile organic contaminants are all dense, nonaqueous-phase liquids (DNAPLs) and

therefore have the potential to collect in pools or in fractures in the bedrock at the bottom of the upper HSU.

If such pools of DNAPLs exist, there is a potential for them to remain as source areas even after the removal

of other sources.

2.4.2 Release Mechanisms

Radionuclides in surface soils may be released via fugitive dust and wind erosion to the air (Figure 2-15). Once

in the air, the contaminated dust will either settle on plants, soils, or water. There is considerable evidence

supporting this release mechanism as plutonium/americium-contaminated soil exists downwind on and in the

vicinity of the Rocky Flats Plant. There is also potential for these contaminants to enter other media via surface

runoff, infiltration/percolation, and biotic uptake.

Contaminants in buried waste can directly enter either the air via volatilization, or the ground water via

infiltration/percolation. Ground-water quality data indicate extensive contamination in the upper HSU including

the alluvium, claystone, siltstone, and Sandstone No. 1. Contamination can also enter surface water through

seepage.

There is also potential for contaminants in the upper HSU to impact the lower HSU. Contaminated alluvial

ground water may potentially enter lower sandstones, where they subcrop beneath the colluvium on the valley

side slopes. Another potential mechanism of release into the lower HSU is by leakage through the weathered

and unweathered claystone bedrock downward to a lower sandstone layer. This release mechanism is judged

to have a low probability at this time as a result of the low hydraulic conductivity values reported in the unweathered claystone units. However, there is a potential for DNAPLs to infiltrate down through fractures in

the bedrock. This would be most likely to occur in depressions or low areas in the bottom surface of the upper

HSU. Although well logs for most pre-1986 wells do not exist, ground-water chemical data and the depth of

the wells suggest wells may be screened across more than one sandstone unit, thus representing another

potential mechanism for contaminant release into the lower HSU.

2.4.3 Potential Exposure Pathways

Exposure to radionuclides in surface soils can occur through multiple pathways (Figure 2-15). This figure

shows all potential pathways; however, the actual pathways of significance will be determined during the risk

assessment. Of primary importance is exposure through direct inhalation of contaminated dust or by ingestion

of contaminated soils. An important secondary exposure route is through ingestion of surface water

contaminated via runoff.

Exposure to contaminants in surface water can occur through direct ingestion or dermal contact, or by

consumption of vegetation or biota where biotic uptake has occurred.

The primary potential pathways for migration of contaminants through ground-water flow to potential receptors

would be either by seepage to the ground surface or by pumping from water supply wells that tap the affected

ground water downgradient of the site. It should be noted that there are currently no known water supply wells

which tap affected ground water. Other exposure pathways may include contamination of surface water by

the interaction of surface water and ground water.

2.4.4 Receptors

Figure 2-15 summarizes the exposure routes and potential receptor populations via the potential exposure

pathways described above. For each pathway, there are three potential exposure routes: ingestion, inhalation,

and dermal contact. Whether the human receptor is a resident or visitor will be determined during the risk

assessment. Biota may also be present at or downgradient of seep locations. The potential for exposure and

magnitude of risk (Figure 2-15) will be assessed during the risk assessment.

2.4.5 Summary

The elements of the site conceptual model described above are shown in Figures 2-14 and 2-15. These figures

depict the potential sources of contamination, mechanisms of contaminant release, exposure pathways, and

primary receptors. The model as pictured is based on an initial evaluation of available data. As additional

information is obtained, the overall model and specific portions of the model (for example, the lower

hydrostratigraphic ground-water flow regime) may be refined or expanded to address the issues of concern.

2.5 SAMPLING AND ANALYSIS REQUIREMENTS FOR REMEDIAL ALTERNATIVES EVALUATION

The purpose of this section is to preliminarily identify potential remedial technologies which are consistent with the available information regarding contamination at OU No. 2. Based on the available site information, the contaminated media or areas for which remedial alternatives will be developed include wastes, soil/sediment, ground water, and surface water. The following preliminary general remedial response actions have been identified for further review and evaluation at this time:

- Complete or partial removal and treatment of wastes and contaminated soils.
- In situ contaminated soils treatment.
- Ground-water collection.
- Infiltration and ground-water containment controls.
- In situ ground-water treatment/immobilization.
- Ground-water/surface water treatment.
- Treated ground-water/surface water disposal.

Additional response actions may be identified, interactively, as the FS proceeds. Combinations of these general response actions may be appropriate and will be evaluated during the FS. Table 2-17 presents these general response actions along with potential component technologies.

As shown in Table 2-18, there are specific requirements that are necessary to evaluate the preliminarily identified technologies. These data will provide for a thorough comparative evaluation of the technologies with respect to implementability, effectiveness, and cost, and allow for informed decisions to be made with respect to selection of preferred technologies. The FSP (Section 5.0) reflects these information requirements.

TABLE 2-17

RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES

GENERAL RESPONSE ACTIONS	TYPICAL REMEDIAL TECHNOLOGIES
Complete or Partial Removal and Treatment of Contaminated Soils	 Off-Site Landfill On-Site Treatment*/Backfill
In Situ Contaminated Soils Treatment	 Immobilization (cementation and vitrification) Soil Flushing Vapor Extraction/Steam Stripping Bioreclamation
Ground-Water Collection	Well ArraySubsurface Drains
Infiltration and Ground-Water Containment Controls	CappingSubsurface Barriers
In Situ Ground-Water Treatment/ Immobilization	ImmobilizationAerationBioreclamation
Ground-Water/Surface Water Treatment	 Biological Treatment UV/Peroxide or UV/Ozone Air Stripping Carbon Adsorption Ion Exchange Electrodialysis Coagulation/Filtration

* Thermal Treatment, Solvent Extraction, Immobilization (Cementation and Vitrification), Attrition Scrubbing for Radionuclide Decontamination

TABLE 2-18

REMEDIAL TECHNOLOGY DATA REQUIREMENTS

<u>TECHNOLOGY</u>	DATA PURPOSE	DATA NEEDED*
Off-Site Disposal	Evaluate whether material is acceptable for off-site disposal	 Determination of applicable RCRA waste codes (40 CFR Part 261). Determination of corresponding 40 CFR Part 268 requirements to establish necessary testing if any. Full Suite of Radionuclide Analyses
	Cost Analysis	- Vertical and Horizontal Extent* of Contamination
On-Site Treatment/Backfill:		
Thermal Treatment	Effectiveness	- Full Suite of Organic and Inorganic Analyses*
•	Cost Effectiveness	- BTU Content - Ultimate Analysis**
Solvent Extraction	Effectiveness	 Soil Type (adsorption characteristics) Soil Organic Matter Content (adsorption characteristics)
Non In Situ (soils) Immobilization/ Cementation	Determine Viscosity of Grout Material	- Soil Grain Size Distribution (sieve analysis)
Non In Situ (soils) Immobilization/ Vitrification	Effectiveness	- Depth of Contamination - Depth of Water Table - Soil Permeability - Metal Content
Attrition Scrubbing	Effectiveness	- Radionuclide Distribution vs. Soil Grain Size
<pre>In Situ Immobilization/Cementation (soils)</pre>	Determine Viscosity of Grout Material	- Soil Grain Size Distribution (sieve analysis)
<pre>In Situ Immobilization/Vitrification (soils)</pre>	Effectivness	- Depth of Contamination - Depth of Water Table - Soil Permeability - Metal Content
Soil Flushing/Bioreclamation	Effectiveness .	- Soil Organic Matter Content - Soil Classification - Soil Permeability - BOD
Vapor Extraction	Effectiveness	- Subsurface Geological Characteristics - Depth to Ground Water - Soil Permeability
Well Array/Subsurface Drain	Hydraulic conductivity Storativity (transient flow)	- Aquifer tests - Hydrogeologic characteristics
ß		Sheet 1 of 2



REMEDIAL TECHNOLOGY DATA REQUIREMENTS

<u>TECHNOLOGY</u>	DATA PURPOSE	DATA NEEDED*
Capping/Subsurface Barriers	Suitability of On-Site Soils for Use	Gradation (Sieve Analysis)Atterberg Limits (Plasticity Tests)
	Effectiveness	 Location of Subcropping Sandstones Hydraulic Conductivity of Bedrock Materials
	Construction Feasibility	 Grade Depth to Bedrock % Moisture Compaction (Proctor) Permeability (Triaxial Permeability) Strength (Triaxial or Direct Shear)
Immobilization (Ground Water Contaminants)	Determine Viscosity of Grout Material	- Soil Grain Size Distribution (sieve analysis)
In Situ Aeration (Ground Water)	Effectiveness	 Subsurface Geological Characteristics Depth to Ground Water Soil Permeability
In Situ Bioreclamation (Ground Water)	Effectiveness	- Aquifer Tests - Hydrogeologic Characteristics - Soil Organic Matter Content - Soil Classification - Soil Permeability - BOD - Dissolved Oxygen - NO ₃ , PO ₄ ³ , pH, Eh - Microbial Populations (density, diversity) - Microcosms
Above-Ground Biological Treatment	Effectiveness	- Soil Organic Matter Content - Soil Classification - Soil Permeability - BOD - Full Suite of Organic Analyses
UV Peroxide Oxidation .	Process Control	Iron and ManganeseMetalsHardnessVolatile organics
Air Stripping	Process Control	- Hardness - Iron and Manganese
	Effectiveness	- Volatile organics

The nature and extent of contamination determined through soils and water analyses for the parameters listed in Tables 2-5 and 2-9 is critical to determining the technical feasibility and cost effectiveness of the technologies listed here.

Ultimate analysis is the determination of percent carbon, hydrogen, sulfur, nitrogen, ash, and oxygen by difference for a dried sample

The primary objective of an RFI/RI is to collect the data necessary to determine the nature, distribution, and migration pathways of contaminants. The RI also supports the evaluation of remedial alternatives (EPA, 1987a). The five general goals of an RFI/RI are:

- 1) Characterize site physical features.
- 2) Define contaminant sources.
- 3) Determine the nature and extent of contamination.
- 4) Describe contaminant fate and transport.
- 5) Provide a baseline risk assessment (EPA, 1988a).

DQOs are qualitative and quantitative statements that specify the quality and quantity of data collection required by the RI (EPA, 1987a). Through application of the DQO process, site-specific RI/FS goals are established, and data needs are identified for achieving those goals. This section of the RFI/RI Work Plan reviews conclusions from the Phase I RI as a basis for Phase II RFI/RI objective and identifies data needs to meet the outlined objectives.

3.1 SITE SPECIFIC RFI/RI DQO PROCESS

Through application of the DQOs process, site-specific RFI/RI DQOs are established and data needs are identified for achieving identified goals. DQOs are qualitative and quantitative statements that describe the quality and quantity of data required by the RFI/RI (EPA, 1987a). These determinations are facilitated through the development of DQOs.

DQOs are developed using the following three-stage process:

- STAGE 1 Identify decision types
 - identify and involve data users
 - evaluate available data
 - develop conceptual model
 - specify objectives/decisions

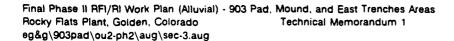
- STAGE 2 Identify data uses and needs
 - identify data uses
 - identify data types
 - identify data quality needs
 - identify data quantity needs
 - evaluate sampling/analysis options
 - review Precision, Accuracy, Representatives, Comparability, and Completeness (PARCC) parameters
- STAGE 3 Design data collection programs
 - assemble data collection components
 - develop data collection documentation

The three stages are implemented for each phase of the RFI/RI. The DQO stages are undertaken in an interactive and iterative manner whereby all the elements of the DQO process are continually being reviewed and applied during the execution of the data collection activities. Throughout the RFI/RI these stages occur in a natural progression and flow together without a formal stage delineation. It may not be possible to identify all data needs during the RFI/RI activity. Data needs will become more apparent as additional data are obtained and evaluated.

3.2 PHASE I RI CONCLUSIONS

Several investigations have been conducted in the vicinity of the 903 Pad, Mound, and East Trenches Areas to date as discussed in Sections 1.0 and 2.0. General conclusions from these investigations are as follows:

- Surficial materials in the area consist of Rocky Flats Alluvium, colluvium, and valley fill alluvium.
- Bedrock beneath surficial materials consists of Arapahoe Formation claystones and sandstones that dip slightly to the east (less than 2 degrees). Bedrock materials are weathered below the base of surficial materials.
- The extent of Arapahoe Formation sandstones beneath these areas was not fully characterized during the Phase I RI because of the complex depositional pattern.
- Unconfined ground-water flow within the upper HSU occurs in surficial materials, subcropping sandstones, and potentially in weathered subcropping claystones. The flow system in surficial materials is not fully saturated year round. Flow in weathered claystones has not been sufficiently documented, and flow directions in subcropping sandstones are poorly defined due to the complex stratigraphy.



- Confined ground-water flow occurs in deeper sandstones (lower HSU). The flow system is poorly defined at this time due to the complex stratigraphy and facies changes.
- Ground-water recharge occurs as infiltration of incident precipitation and flow from ditches and surface water drainages.
- Discharge from the unconfined ground-water flow system occurs as evapotranspiration, seeps, and springs at the edge of the Rocky Flats pediment, to surface water in Woman Creek and South Walnut Creek, and to bedrock sandstones. Site contaminants have been identified in many of these seeps.
- Wastes have been removed from the 903 Drum Storage Site, the Pallet Burn Site, the Oil Drum Pit No. 2 Site, and the Mound Site. Wastes remain in place in all 11 trenches within the area. Further characterization of all potential contaminant sources is warranted.
- Boreholes were drilled adjacent to IHSSs in the Phase I RI, and soil samples were collected and analyzed for Hazardous Substances List (HSL) organics and metals, radionuclides, and inorganics. Further characterization of soils beneath IHSSs is needed.
- Surficial soils in the area are contaminated with plutonium, americium, and other radionuclides
 due to wind dispersal of particulates during clean up of the 903 Drum Storage Site in the late
 1960s. Soil sampling results indicate that these compounds are most enriched near the
 surface, but further investigation of smaller soil intervals is necessary to assess radionuclides
 distribution.
- The upper HSU contains volatile organic compounds. The principal volatile organics present are PCE, CCL₄, and TCE. The extent of these contaminants in both the unconfined and confined ground-water flow systems has not been fully determined.
- Radionuclides were elevated in sediment and unfiltered surface water samples collected during
 the Phase I RI. Wind dispersal of radionuclides during clean up of the 903 Drum Storage Site
 is the likely source of these contaminants, although confirmation of this hypothesis is needed.
 There are slight indications of radionuclides in a few ground-water wells (unvalidated).
- Several major and minor elements were elevated above background in soils, ground water, surface water, and sediments, but they do not exhibit clear lateral or vertical gradients.

3.3 SITE-SPECIFIC PHASE II RFI/RI OBJECTIVES AND DATA NEEDS

Based on the Phase I RI conclusions and the conceptual site model presented in Section 2.0, site-specific Phase II RFI/RI objectives and associated data needs have been developed (Table 3-1). Specific plans for obtaining the needed data are presented in Section 5.0 (FSP).

High quality data will be collected by following the Rocky Flats Plant ER Program Standard Operating Procedures (SOP) (EG&G, 1990i), through adherence to the Rocky Flats Plant ER Program Quality Assurance Project Plan (QAPjP) (EG&G, 1990j), the QAA (Section 9.0), and the General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G, 1990k). Organic and metal analyses will be performed using CLP routine analytical services (RAS), and other analyses (radionuclides and inorganics) will be performed in accordance with the GRRASP-specified methods. In addition, analytical methods with detection limits below

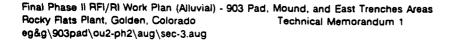


TABLE 3-1

PHASE II RFI/RI OBJECTIVES AND ACTIVITIES

<u>Objecti</u>	<u>ve</u>	Field/Analytical Activity	Analytical Level*	<u>Data Use</u>
<u>Charact</u> <u>Feature</u>	erize Site Physical S			
1)	Determine the extent of saturation and ground- water flow directions for the unconfined flow	 Additional monitoring well and piezometer data in unexplored areas. 	NA	 Site Characterization Alternatives Evaluation
	system both spatially and temporally.	 Water level data from various units from all existing and new monitor wells. 		
2)	Describe the inter- action between the sur- face water and ground- water pathways.	 Ground-water flow directions, quality, and potentiometric surface. 	<pre>II(field) IV*(off-site analytical)</pre>	 Site Characterization Alternatives Evaluation
	auto putinojo:	 Seep locations, flow, and water quality. 		
3)	Determine the hydraulic connection between surficial deposits and bedrock and quantify material properties	 Long term pumping test data to evaluate hydraulic conductivity and stora- tivity. 	NA	 Site Characterization Alternatives Evaluation
		 Tracer test data to evaluate effective poro- sity. 		
4)	Delineate the Arapahoe Formation sandstones	 Additional drilling and seismic profile data. 	NA	 Site Characterization Alternatives Evaluation
Charact	erize Contaminant Sources			
1)	Characterize the nature and distribution of waste materials re- maining on-site.	 Chemical analyses of wastes and soils beneath the wastes. Analyze samples for TCL volatiles, semi-volatiles,pesticides/ PCBs, and Target Analyte List (TAL) metals, as well as radionuclides and inor- ganics. 	IV	 Site Characterization Alternatives Evaluation Risk Assessment

TABLE 3-1 (Continued)

PHASE II RFI/RI OBJECTIVES AND DATA NEEDS

<u>Objective</u>		Field/Analytical Activity Analytical Level		<u> Data Use</u>	
Charac (Contin	<u>erize Contaminant Sources</u> <u>ued)</u>	·			
2)	Characterize soils beneath wastes as well as soils at sites where wastes have been removed as potential contaminant sources.	· Same as above.	IV	 Site Characterization Alternatives Evaluation Risk Assessment 	
3)	Identify which sites are sources of ground-water and surface water contamination.	 Ground-water levels and quality beneath sites. IHSS specific upgradient and downgradient water quality data. Additional surface water quality data from existing seep stations. 	· IV	Site Characterization Alternatives Evaluation Risk Assessment	
	erize the Mature and of Contamination				
1)	Determine the horizon- tal and vertical extent of surficial radionu- clide soil contamina- tion due to wind dis- persion.	Radionuclide data on surficial soil scrapes. Sampling will follow Colorado Department of Health procedures. To define the horizontal extent of radionuclide contamination, these samples will be collected within the RF1/R1 study area as well as in the Plant buffer zone.	IV	· Site Characterization · Alternatives Evaluation · Risk Assessment	
		 Radionuclide data on soil samples from test pits dug in the same areas as sur- ficial soil sample collec- tion to define the verti- cal extent of radionuclide migration into the soil profile. 			

TABLE 3-1 (Continued)

PHASE II RFI/RI OBJECTIVES AND DATA NEEDS

<u>Objecti</u>	<u>ve</u>	Field/Analytical Activity	Analytical Level	<u>Data Use</u>
	erize the Nature and Extent amination (Continued)		:	,
2)	Determine the nature and extent of ground-water contamination.	Ground-water chemistry data for surficial materials and subcropping Arapahoe sandstones between areas with and without known ground-water contamination to delineate the extent of contamination. Samples will be analyzed for TCL volatiles, semi-volatiles and pesticides/PCBs, TAL metals, radionuclides, and inorganics	IV	 Site Characterization Alternatives Evaluation Risk Assessment
3)	Characterize surface water and seep quality.	Quarterly collection of surface water seep samples from existing monitoring stations. Samples will be analyzed for TCL volatiles, TAL metals, radionuclides, and inorganics. Analyze surface water samples for both dissolved and total metals and radionuclides to determine if constituents are suspended or dissolved. Continue routine flow rate measurements at surface water stations.	IV	 Site Characterization Alternatives Evaluation Risk Assessment
Provide Assessm	Data for Baseline Risk ment			
1)	Describe contaminant fate and transport.	Data on the physicochemical processes associated with site contaminants based on existing literature and site specific information.	. NA	Risk Assessment

TABLE 3-1 (Continued)

PHASE II RFI/RI OBJECTIVES AND ACTIVITIES

<u>Objective</u>		Field/Analytical Activity	Field/Analytical Activity Analytical Level		
	de Data for Baseline Assessment (continued)				
2)	Assess potential interim and final remedial alternatives.	Information on the effec- tiveness of interim and final remedial alterna- tives.	NA	· Risk Assessment	
3)	Assess the threat to public health and the environment from the no action remedial alternative.	Reference doses and slope factors for contaminants at the site.	NA .	Risk Assessment	
Provid Study	de Data for Feasibility				
1)	Assess potential interim and final remedial alternatives.	Information on the effectiveness, implementability, and cost of interim and final remedial alternatives. This includes: site geological and hydrogeochemical data; literature data on remedial alternatives performance; treatability study data; and design, construction, and operation and maintenance costs for remedial alternatives.	IV (treatability studies)	Alternatives Evaluation	
<u>Provid</u> Evalua	de Data for Environmental		;		
1)	Assess the bio- availability and toxicity of the contaminants to the flora and fauna.	field assessments, toxicity testing, and biomarkers to determine ecological effects.	1 V	 Site Characterization Alternatives Evaluation Risk Assessment 	

See Table 3-2 for explanation

Radionuclides are considered non-conventional parameter and therefore the analytical level for these constituents is "V"

Not applicable

or near chemical-specific ARARS are presented in Section 7.0 (Table 7-1) and will be used to facilitate comparison of resulting data to ARARs. Table 3-2 explains the required analytical levels referenced in Table 3-1.

TABLE 3-2

LEVEL OF ANALYSIS

Required Analytical Level	Task
Level I (Field Screens)	Water level measurement
,	 pH measurement
	Eh measurement
	 Screening for organics (OVA/HNu)
	 Screening for radionuclides (beta-gamma)
	 Temperature
•	Specific conductance
	Geophysical surveys
Level II (Field Analyses)	 Screening for organics (GC)
	 Screening for radionuclides (gross)
	beta/gross alpha, gamma spec)
	 Analysis of engineering properties
Level III (Laboratory Analyses	Major ion analysis
using EPA Standard Methods)	Organics analysis
	 Inorganics analysis
Level IV (Laboratory Analyses	Analysis of Target Compound List (TCL)
using EPA CLP Methods)	and Target Analyte List (TAL)
Level V (Nonstandard Analyses)	Radiological analyses
, ,	Chemical analyses requiring modification of standard methods
	Special Analytical Services (SAS)

Source: EPA, (1987a)

4.1 REMEDIAL INVESTIGATION TASKS

4.1.1 Task 1 - Project Planning

The project planning task includes all efforts required to initiate this Phase II RFI/RI of OU No. 2. Activities undertaken for this project have included a detailed review of the Phase I RI results as well as other previous investigation results, a review of historical aerial photography, a preliminary evaluation of ARARs, and scoping of the Phase II RFI/RI. Results of these activities are presented in Sections 1.0 (Introduction) and 2.0 (Phase I RI Site Evaluation).

During the Phase I RI, a complex depositional pattern was recognized in the bedrock beneath the 903 Pad, Mound, and East Trenches Areas. A high resolution seismic reflection program is currently being implemented to further define the location, extent, and orientation of bedrock sandstone units beneath the area. Results of this investigation will be evaluated in scoping of the Phase II RFI/RI (Bedrock) for OU No. 2.

Two project planning documents, including this work plan, have been prepared that pertain to this Phase II RFI/RI as required by the IAG between DOE, EPA, and CDH. This work plan presents results of the project planning task in addition to plans for the Phase II RFI/RI. An FSP is included in this document (Section 5.0) that presents the locations, media, and frequency of sampling efforts. The second document required by the IAG is a Sampling and Analysis Plan (SAP). The IAG specifies that the SAP is to include a QAPjP and SOP for all field activities. A draft QAPjP for site-wide RCRA and CERCLA activities (EG&G, 1990j) was submitted to the regulatory agencies in August 1990. A GRRASP (EG&G, 1990k) has also been prepared which is the scope of work for analytical services. The current Rocky Flats Plant SOPs were submitted to EPA and CDH in August 1990 (EG&G, 1990i). A Health and Safety Plan (HSP) defining the protocol for protection of field workers during Phase II operations will be submitted as well. The HSP will be based on the Health and Safety Program Plan currently being finalized based on comments from EPA and CDH.

4.1.2 Task 2 - Community Relations

In accordance with the draft IAG, the Rocky Flats Plant is developing a Community Relations Plan (CRP) to inform and actively involve the public in decision making regarding environmental restoration activities. The plan will address the needs and concerns of the surrounding communities as identified through approximately

80 interviews with federal, state, and local elected officials; businesses; medical professionals; educational

representatives; interest groups; media; and residents adjacent to the Plant.

The draft CRP was submitted to EPA and CDH for review in November 1990 in accordance with the draft IAG

schedules. Accordingly, a site-specific CRP is not required for OU No. 2. Following review by EPA and CDH,

the proposed plan was distributed for public review and comment in January 1991. The proposed CRP is

scheduled for finalization in August 1991.

During the February 1990 public hearing on the IAG, several commentators requested the development of an

Interim CRP for implementation until the final plan is available in August 1991. A draft Interim CRP was

prepared and implemented in January 1991 pending finalization of the proposed plan.

Current community relations activities concerning environmental restoration include: participation by Plant

representatives in informational workshops; meetings of the Rocky Flats Environmental Monitoring Council;

briefings for citizens, businesses, and surrounding communities on environmental restoration and monitoring

activities; and public comment meetings on various ER Program plans and actions.

In addition, a Speakers Bureau provides Plant speakers for presentations to civic groups and educational

organizations, and a public tours program allows the public to visit the Rocky Flats Plant. The Plant also

produces fact sheets and periodic updates on environmental restoration activities for public information and

responds to numerous public inquiries concerning the Plant.

4.1.3 Task 3 - Field Investigation

The Phase II RFI/RI field investigation is designed to meet the objectives outlined in Section 3.2. The following

activities will be performed as part of the field investigation:

Drill and sample soils and wastes within IHSSs.

Sample surficial soils for radionuclides, and subsurface soils for radionuclides, TCL volatiles, semi-volatiles, pesticides/PCBs, TAL metals, inorganics and soil physical characteristics (e.g.,

organic matter ambient, grain size distribution, cation exchange capacity, etc.).

Install and sample ground-water monitoring wells to characterize the nature and extent of

ground-water contamination and the hydraulic connection between surficial materials and

bedrock.

Perform aquifer tests, tracer tests, and geotechnical tests.

Collect surface water and sediment samples.

Take water level measurements, stream flow measurements, and ground-water quality parameters.

Sample locations, frequency, and analyses are presented in Section 5.0. All field activities will be performed

in accordance with the Rocky Flats Plant ER Program SOP (EG&G, 1990i).

4.1.4 Task 4 - Sample Analysis and Data Validation

Analytical methods for chemical analyses are provided in the GRRASP (EG&G, 1990k). Also provided in this

document are the analytical detection limits.

Data will be reviewed and validated by the EG&G Environmental Monitoring and Assessment Division (EMAD)

laboratory validation subcontractor. Results of data review and validation activities will be documented in data

validation reports and the RFI/RI report. EPA data validation functional guidelines will be used for validating

organic and inorganic (metals) data (EPA, 1988b). Validation methods for radiochemistry and major ions data

have not been published by the EPA; however, data and documentation requirements have been developed

by the ER Department. The functional guidelines which will be used to evaluate analytical data are presented

in the QAPjP (EG&G, 1990j) and GRRASP (EG&G, 1990k).

4.1.5 Task 5 - Data Evaluation

Data collected during the Phase II RFI/RI will be incorporated into the Rocky Flats Environmental Database

System (RFEDS) and used to better define site characteristics, source characteristics, the nature and extent

of contamination, and contaminant migration rates. The RFEDS is used to track, store, and retrieve project

data. Data will be input to the RFEDS via diskettes subsequent to data validation as outlined in the ER

Program QAPjP (EG&G, 1990j). Hard copy reports will then be generated from the system for data

interpretation and evaluation.

4.1.5.1 Site Characterization

Geologic and hydrologic data will be incorporated into existing site maps and cross-sections. Geologic data

will be used to detail the stratigraphy of surficial materials and weathered bedrock within source areas and to

map the extent of paleochannels in the top of bedrock. Hydrologic data will be used to evaluate seasonal

variations in water levels, ground-water flow, and the extent of saturated surficial materials. Also evaluated will

be hydraulic conductivity, storativity, ground-water velocity, contaminant migration rates, and the interaction

between ground water and surface water.

4.1.5:2 Source Characterization

Analytical data from source boreholes will be used to:

- Verify IHSS locations.
- Characterize the nature of source contaminants.
- Characterize the lateral and vertical extent of source contaminants.
- Determine the maximum on-site contaminant concentrations.
- Quantify the volume of source materials.

At those IHSS locations that are trenches, geologic data from the source boreholes will also determine the trench depths and characterize any trench contents.

4.1.5.3 Nature and Extent of Contamination

Analytical data from soil, sediment, ground-water, surface water, and routine air sampling efforts will be used to characterize the nature and extent of contamination. The criteria for the identification of contamination will be analyte-specific. For organic compounds, any detectable concentrations in samples that are not attributable to laboratory contamination [defined according to CLP Protocol (EPA, 1988b)] will be considered likely evidence of contamination. Unvalidated data or invalid data will be considered qualitative estimates of contamination only. For inorganic compounds (including radionuclides), only those concentrations that exceed expected concentrations in background shall constitute evidence of contamination. The statistical techniques that shall be used to compare concentrations of inorganic compounds collected as part of the Phase II RFI/RI to background concentrations are documented in the Background Geochemical Characterization Report (Rockwell International, 1989h). Essential to the implementation of these statistical techniques for ground-water and borehole samples is the classification of each analytical datum according to an appropriate geologic unit (such as Rocky Flats Alluvium or colluvium). This identification of the appropriate geologic unit will be based on geological data collected during the Phase II RFI/RI. Background for inorganic analytes will be further characterized and evaluated in the context of the potential role of evaporative concentration as a mechanism for localized occurrences of inorganic constituents at high concentrations.

The extent of contamination will be delineated through the use of contaminant isopleths maps and possibly cross sections. The possibility of using kriging to contour the isopleths of the most widely distributed contaminants will be investigated with explicit attention to the assumptions required by kriging (Davis, 1986), and kriged contours will be generated only if appropriate. Investigations to date indicate difficulty in identifying the source of contamination because of the close proximity of several possible sources. The statistical

technique of principal component analysis will be investigated as a method of identifying the effects of multiple

sources. The ability to estimate the individual effects of multiple sources at intermediate sampling sites will aid

in the mapping of plumes and in the understanding of the transport of contaminants by the ground-water flow

system.

Comparisons of analytical data between ground water and surface water will be made to investigate the

movement of contaminants from one pathway to another. Temporal variations of contaminant concentrations

in ground water and surface water will be evaluated both for seasonality and long-term trends to determine

contaminant migration rates.

Analytical data from surficial soil scrapes and vertical soil profiles will be evaluated in order to characterize the

areal and vertical distribution of plutonium and americium contamination in remedial investigation areas and

in other Plant areas (buffer zone) to the south and east.

4.1.5.4 Evaluation of Proposed Remedial Alternatives

The evaluation of proposed remedial alternatives will be based primarily on the information derived for the

purpose of site and source characterization. Geotechnical data from source boreholes will be used to evaluate

the effectiveness of technologies pertinent to soil remediation, e.g.:

Attrition scrubbing

Solvent extraction

Vapor extraction/steam stripping

Soil immobilization

Soil flushing/bioreclamation

In situ vitrification

Capping/subsurface barriers

4.1.6 Task 6 - Baseline Risk Assessment

A baseline risk assessment will be prepared for the 903 Pad, Mound, and East Trenches Areas as part of the

Phase II RFI/RI to evaluate the potential threat to the public health and the environment in the absence of

remedial action. The baseline risk assessment will provide the basis for determining whether or not remedial

action is necessary in the area and will serve as the justification for performing remedial action (EPA, 1988a).

The risk assessment will assume no institutional controls.

Several objectives will be accomplished under the risk assessment task including identification and characterization of the following (EPA, 1988a):

- Toxicity and levels of hazardous substances present in relevant media (e.g., air, ground water, soil, surface water, sediment, and biota).
- Environmental fate and transport mechanisms within specific environmental media and crossmedia fate and transport where appropriate.
- Potential human and environmental receptors.
- Potential exposure routes and extent of actual or expected exposure.
- Extent of expected impact or threat, and the likelihood of such impact or threat occurring (e.g., risk characterization).
- Level(s) of uncertainty associated with the above.

The public health risk assessment and the environmental evaluation will be performed in accordance with EPA and other guidance documents listed in Table 4-1. The risk assessment will address the potential public health and environmental impacts associated with the site under the no-action alternative (no remedial action taken). This assessment will aid in the selection of site remedies based on the contaminants of concern and the environmental media associated with potential risks to public health and the environment.

4.1.6.1 Public Health Evaluation

The risk assessment process is divided into five tasks (EPA, 1988a), including:

- Data collection/contaminant identification
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Analysis of uncertainties

The task objectives and description of work for each task are described below.

Data Collection/Contaminant Identification

The objective of contaminant identification is to screen the information that is available on hazardous substances or wastes present at the site and to identify contaminants for the risk assessment process.

TABLE 4-1

EPA GUIDANCE DOCUMENTS WHICH WILL BE USED IN THE RISK ASSESSMENT TASK

- Risk Assessment Guidance for Superfund, Human Health Evaluation Manual Part A, Interim Final -Office of Emergency and Remedial Response. This volume provides updated risk assessment
 procedures and policies, specific equations and variable values for estimating exposure, and a
 hierarchy of toxicity data sources. There is an expanded chapter on risk characterization to help
 summarize information for the decision makers and detailed descriptions of uncertainties in risk
 assessment (EPA, 1989a).
- OSWER Directive on Soil Ingestion Rates -- Office of Solid Waste and Emergency Response (January 1989), OSWER Directive #9850.4. Recommends soil ingestion rates for use in risk assessment when site-specific information is not available. Available from Darlene Williams, 202-475-9810 (EPA, 1989b).
- Risk Assessment Guidance for Superfund -- Environmental Evaluation Manual, Interim Final (RAGS-EEM) -- Office of Emergency and Remedial Response (March 1989), EPA/540/1-89/001A. Provides program guidance to help remedial project managers and on-scene coordinators manage ecological assessment at Superfund sites (EPA, 1989d).
- <u>CERCLA Compliance With Other Laws Manual</u> -- Office of Emergency and Remedial Response. The
 guidance is intended to assist in the selection of on-site remedial actions that meet the applicable or
 relevant and appropriate requirements (ARARs) of the Resource Conservation and Recovery Act
 (RCRA), Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Clean Air Act (CAA) and other
 federal and state environmental laws as required by CERCLA, Section 121 (EPA, 1988d).
- <u>Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference</u> -- Office of Solid Waste and Emergency Response EPA 600-3/89/013. This report is a field and laboratory reference document that provides guidance on designing, implementing, and interpreting ecological assessments of hazardous waste sites. It includes sections on ecological endpoints, field sampling design, quality assurance, aquatic and terrestrial toxicity and field survey methods, recommended biomarkers, and data analysis (EPA, 1989c).
- <u>EPA's Integrated Risk Information System (IRIS)</u> -- Office of Research and Development (continuously updated). Agency's primary source of chemical-specific toxicity and risk assessment information. Includes narrative discussion of toxicity database quality and explains derivation of Reference Doses, cancer potency factors, other key dose response parameters. IRIS presents information that updates data originally presented in Exhibits A-4 and A-6 of the SPHEM (see below). Further information: IRIS Users Support, 513-569-7254 (EPA, 1987b).
- <u>Exposure Factors Handbook</u> -- Office of Research and Development (March 1989), EPA/600/8-89/043. Provides statistical data on the various factors used in assessing exposure; recommends specific default values to be used when site-specific data are not available for certain exposure scenarios. Further information: Exposure Methods Branch, 202-382-5988 (EPA, 1989e).
- <u>Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA</u> -- Office of Emergency and Remedial Response EAA/540/G-89/004. This guidance document is a revision of the U.S. EPA's 1985 guidance. It describes general procedures for conducting an RI/FS (EPA, 1988a).

TABLE 4-1 (Continued)

EPA GUIDANCE DOCUMENTS WHICH WILL BE USED IN THE RISK ASSESSMENT TASK

- Health Effects Assessment Summary Tables (HEAST) -- Office of Research and Development/Office of Emergency and Remedial Response (updated quarterly). Since the IRIS chemical universe (while growing), is currently incomplete, the HEAST has been produced to serve as a "pointer" system to identify current literature and toxicity information on important non-IRIS chemicals. While HEAST data in some cases may be "Agency-verified", the information is considered valuable for Superfund risk assessment purposes. Available from Superfund docket, 202-382-3046 (EPA, updated quarterly).
- <u>Superfund Exposure Assessment Manual (SEAM)</u> -- Office of Emergency and Remedial Response (April 1988), EPA/540/1-88/001. Provides a framework for the assessment of exposure to contaminants at or migrating from hazardous waste sites. Discusses modeling and monitoring* (EPA, 1988c).
- Superfund Public Health Evaluation Manual (SPHEM) -- Office of Emergency and Remedial Response.
 The current program risk assessment guidance manual. Explains how to set preliminary remediation goals, and evaluate risks of remedial alternatives.
- <u>Superfund Risk Assessment Information Directory (RAID)</u> -- Office of Emergency and Remedial Response (November 1986), EPA/540/1-86/061. Describes sources of information useful in conducting risk assessments. Currently under revision.
- Available from Center for Environmental Research Information, 513-569-7562.

Sheet 2 of 2

Previous work characterizing aspects of the Rocky Flats Plant and the surrounding area has been done. Additional sampling and analysis of various media will take place in order to support the human health risk assessment, the ecological assessment, and to further characterize the site. For this risk assessment, all chemicals detected above background concentrations in site-associated media at OU No. 2 will be treated as site contaminants for the purpose of public health evaluation. These include:

- Chemicals positively identified in one or more samples in a given medium.
- Chemicals which have been tentatively identified and have historically been associated with the site or confirmed by special analysis.

The potential transformation products of site-associated chemicals will be considered to the extent possible by the availability of chemical-specific transformation data and information regarding site-specific environmental conditions (e.g., potential for biodegradation).

All chemicals present below background will be eliminated from further consideration. In addition, after the completion of the exposure assessment, any site contaminants which appear to have no potential for exposure will not be evaluated. All chemicals that are deleted and the rationale for their deletion will be discussed.

Exposure Assessment

The objectives of the exposure assessment are to identify actual or potential exposure pathways, to characterize potentially exposed populations, and to determine the extent of exposure. A conceptual model for exposure assessment is shown in Figure 2-16. An exposure pathway is comprised of four elements:

- A source and mechanism of chemical release to the environment.
- An environmental transport medium (e.g., air, ground water) for the released constituent.
- A point of potential contact of humans or biota with the affected medium (the exposure point).
- An exposure route (e.g., inhalation of contaminated dust) at the exposure point.

The exposure assessment process will include the following actions:

- Analyze the probable fate and transport of compounds for both the present and the future uses.
- Identify the human populations in the area, typical activities that would influence exposure, and sensitive population subgroups.
- Identify potential exposure pathways under current and future land use conditions.

- Develop exposure scenarios for each identified pathway and select those scenarios that are plausible.
- Identify scenarios assuming both existing and potential future uses.
- Identify the exposure parameters to be used in assessing the risk for all scenarios.
- Develop an estimate of the expected exposure levels from the potential release of contaminants.

Appropriate exposure scenarios will be identified for the site. Scenarios that could potentially be considered include residential, commercial/industrial, and/or recreational. Factors to be examined in the pathway and receptor identification process will include:

- Location of contaminant source.
- Local topography.
- Local meteorological data.
- Local geohydrology/surface water hydrology.
- Surrounding land use.
- Local water use:
- Prediction of contaminant migration.
- Persistence and mobility of migrating contaminants.

For each migration pathway and for current and future conditions, receptors will be identified and characterized. Potential receptors will be defined by the appropriate exposure scenarios.

To assess the potential adverse health effects associated with access to the site, the potential level of human exposure to the selected chemicals must be determined. Intakes of exposed populations will be calculated separately for all appropriate pathways of exposure to chemicals. Then for each population-at-risk, the total chronic intake by each route of exposure will be calculated by adding the intakes from each pathway. Total oral, inhalation, and dermal chronic exposures will be estimated separately. Chronic daily intakes will be calculated based on the upper 95 percent confidence limit of the exposure data.

In general, chemical intakes will be estimated using available, region-specific exposure parameters developed by the EPA. Any deviation from these parameters will be documented and submitted to the regional EPA office for approval prior to preparation of the risk assessment.

Toxicity Assessment

In accordance with EPA's risk assessment guidelines, the projected concentrations of chemicals of concern at exposure points will be compared with ARARs to judge the degree and extent of risk to public health and the environment (including plants, animals, and ecosystems). Because many ARARs do not exist for certain media (such as soils) nor are all ARARs necessarily health based, this comparison is not sufficient in itself to satisfy the requirements of the risk assessment process. Moreover, receptors may be exposed to contaminants from more than one medium so that their total doses might exceed risk reference doses (RfDs) and/or might result in an excess cancer risk greater than an acceptable target risk, as defined by EPA (e.g., 10⁻⁸ to 10⁻⁴). Nevertheless, the comparison with standards and criteria is useful in defining the exceedance of institutional requirements. Aside from the ARARs discussed in Section 7.0, the following criteria will be examined:

- Drinking water health advisories.
- Ambient water quality criteria for protection of human health.
- Center for Disease Control and Agency for Toxic Substances and Disease Registry soil advisories.
- National Ambient Air Quality Standards.

Critical toxicity values (e.g., numerical values derived from dose-response information for individual compounds) will be used in conjunction with the intake determinations to characterize risk. Toxicity reference values from EPA's Integrated Risk Information System (IRIS) will be used in preference to other EPA reference values.

A summary of any toxicological studies performed will be provided for all chemicals above background in the baseline risk assessment. The quality of these studies and their usefulness in estimating human health risks will be described. A more detailed explanation of the toxic effects of target chemicals will be provided in the appendices to the human health risk assessment and the environmental evaluation. Toxicity reference values will also be summarized. For the human health risk assessment, this will include a brief description of the studies upon which selected reference values were based, the uncertainty factors used to calculate RfDs, and the EPA weight-of-evidence classification for carcinogens. For those chemicals without EPA toxicity reference values, a literature search, including computer data bases, will be conducted for selected compounds. A toxicity value will then, if possible, be derived from this information. EPA will be consulted regarding the appropriateness of the data and the methodologies to be used in deriving reference values. Uncertainties regarding the toxicity assessment will be discussed.

Two types of critical toxicity values will be used:

The risk reference dose (RfD).

Slope factor (for carcinogenic chemicals only).

Risk Characterization

Risk characterization involves integrating exposure assumptions and toxicity information to quantitatively

estimate the risk of adverse health effects. Risk characterization will be performed in accordance with EPA

guidance.

Non-carcinogenic risk will be evaluated by comparison of contaminant intakes at exposure points to chronic

reference doses for protection of human health. Carcinogenic risk will be quantified using carcinogenic

potency factors. Risk will be qualitatively evaluated for those contaminants for which evaluation is not possible.

The results of the baseline risk assessment will be used to define and evaluate the remedial alternatives during

the FS.

Uncertainty Analysis

An uncertainty analysis will be performed to identify and evaluate non-site and site-specific factors that may

produce uncertainty in the risk assessment, such as assumptions inherent in the development of toxicological.

endpoints (potency factors, reference doses) and assumptions considered in the exposure assessment (model

input variability, population dynamics). First order or statistical sampling (Monte-Carlo) techniques may be

employed. The goal of this task will be to quantify, to the extent practicable, the magnitude and extent of

uncertainty propagated through the risk assessment process. The uncertainty analysis will present the

spectrum of potential risks under specified scenarios so the risk management decision maker can obtain an

understanding of the level of confidence associated with all estimates of potential human health risk.

4.1.6.2 Environmental Evaluation

The EEWP for OU No. 2 is presented in Section 6.0. The principal focus of the EEWP is on an environmental

evaluation methodology which is described in Section 6.3. The basic methodological components are

addressed in detail. The overall purpose of the OU No. 2 EE is to document a qualitative and, where possible,

a quantitative assessment of actual or potential threats of damage to the environment including wildlife and

vegetation species, habitats, and sensitive ecosystems.

The EEWP is based on:

- The EPA's mandate under the CERCLA, or Superfund, to protect human health and the environment from actual or threatened releases of hazardous substances.
- The requirement of the National Contingency Plan (NCP) [300.430(e)(2)(G)] to perform EEs at CERCLA sites in order to assess threats to the environment.
- The EPA Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual (EPA, 1989a).
- The FFCAO entered into between the DOE, EPA Region VIII, and the State of Colorado, also known as the IAG, which requires the DOE to perform environmental response activities at the Rocky Flats Plant that are consistent with the requirements of CERCLA and other applicable federal and state laws and regulations.

The EEWP provides a generalized overview of the Rocky Flats Plant, establishes EE purposes and objectives, details an EE methodology, and identifies specific tasks to be undertaken as part of the EE implementation process in order to assess actual or potential ecological consequences of releases of contaminants from the 903 Pad, Mound, and East Trenches Areas assuming no remedial action.

The EEWP describes the process by which actual and potential environmental risks deriving from existing OU No. 2 conditions will be assessed, relying in part on data collected during the Phase I RI and Phase II RFI/RI. When the EEWP is implemented, it will characterize the levels of toxicity of hazardous substances present in the environment, the fate and transport of contaminants, and the actual and potential exposure of contaminants to plants and animals. The EE approach has much in common with the human health risk assessment in that the same basic steps are employed: data collection and evaluation, contaminant identification, exposure assessment, toxicity assessment, and risk characterization. The major guidance document that will be relied upon in implementing the EEWP is the EPA Environmental Evaluation Manual (EPA, 1989d).

Ten specific tasks under which the EE will be organized and performed are identified in Section 6.1.1. These tasks are as follows:

- Task 1 -- Preliminary Planning
- Task 2 -- Data Collection/Evaluation and Conceptual Model Development
- Task 3 -- Ecological Field Investigation
- Task 4 -- Toxicity Assessment
- Task 5 -- Exposure Assessment and Pathways Model
- Task 6 -- Preliminary Contamination Characterization
- Task 7 -- Uncertainty Analysis
- Task 8 -- Planning

- Task 9 -- Ecotoxicological Field Investigation
- Task 10 -- Environmental Evaluation Report

EE program flexibility will be required as the nature and scope of any particular task may need to be modified depending on changes in the existing database, the results of qualitative field surveys, and the data derived from the quantitative field sampling and analysis.

The EEWP FSP will be integrated with the OU No. 2 Phase II RFI/RI field sampling program given in Section 5.0, as well as sampling by the Rocky Flats EMAD. The sampling procedures discussed have been designed to follow protocols already in place at the Rocky Flats Plant and those recommended by EPA and the U.S. Fish and Wildlife Service. Overall objectives of the FSP are to: (1) characterize biological resources in order to conduct the ecological impact assessment, and (2) acquire data needed to measure the effects of contaminants on ecological systems.

The FSP will consist of both qualitative field surveys and quantitative field sampling. Both programs will identify, characterize and assess aquatic ecosystems (periphyton, benthic macroinvertebrates, and fish) and terrestrial organisms (grassland vegetation, small mammals, invertebrates, and wetlands). The FSP also addresses QA/QC, sample documentation, equipment calibration and maintenance, health and safety, waste management, sample handling and analytical protocols, and statistical analysis and procedures.

4.1.7 Task 7 - Treatability Studies/Pilot Testing

A draft Treatability Studies Plan (TSP) (EG&G, 1990I) was prepared and submitted to the regulatory agencies in September 1990 in accordance with the draft IAG schedule. This document provides comprehensive plans for treatability studies designed for remediation of waste sources, soils, and water at all operable units at Rocky Flats Plant. The Treatability Studies Program that is addressed by the TSP will serve to determine the operability, reliability, cost-effectiveness, and overall implementability of technologies that are appropriate for the types of contaminants and contaminated media at the Plant but are not adequately proven.

The Treatability Studies Program will address practical (e.g., conventional) technologies and innovative/emerging technologies. The TSP identifies both practical and innovative technologies that are applicable to the Rocky Flats Plant contamination, screens these technologies to determine candidates for treatability studies, and provides statements of work for each candidate treatability study. Subsequently, work plans will be prepared for conduct of the treatability studies. The treatability studies will then be performed, and a treatability studies report (draft report due in May 1993) will be prepared. The report timing will allow utilization of this information for the OU No. 2 CMS/FS report (draft report due November 1993). However, the draft IAG schedules for OU No. 2 also call for scoping of treatability studies specific to OU No. 2 beginning

in October 1992, with studies completed by June 1993. During the scoping of treatability studies, the need to acquire additional data on the technologies relevant to OU No. 2 will be determined. Work plans will subsequently be prepared as appropriate. Results of treatability studies performed pursuant to the surface water IM/IRA will be evaluated in determining the need to acquire additional data.

The Treatability Studies Program and the OU No. 2 treatability studies (for IM/IRA and CMS/FS) will be a coordinated effort with common project control. The staff assigned for project control will also supervise site-specific treatability studies for other OUs as well as the Rocky Flats Plant contributions to the DOE Office of Technology Development (OTD) integrated demonstrations and the EPA Superfund Innovative Technology Evaluation (SITE) program. For example, the treatability studies project staff are participating in OTD's integrated demonstrations of plutonium in soils that is being conducted at the Nevada Test Site. Participation in the numerous treatability study programs will allow evaluation of all applicable innovative technologies, and will "streamline" each program to avoid duplication of effort.

4.1.8 Task 8 - Remedial Investigation Report

A draft Phase II RFI/RI Report will be prepared to consolidate and summarize the data obtained during Phase I and II RI field work. This report will:

- Describe in detail the field activities which serve as a basis for the RI report. This will include any deviations from the work plan which occurred during implementation of the field investigation.
- Thoroughly discuss site physical conditions. This discussion will include surface features, meteorology, surface water hydrology, surficial geology, ground-water hydrology, demography and land use, and ecology.
- Present site characterization results from all RI investigative activities at OU No. 2 in order to further characterize the nature and extent of contamination as well as the rate of contaminant migration. The media to be addressed will include contaminant sources, soils, ground water, surface water, air, and biota. All relevant quarterly ground-water and surface water sampling results will be used in this assessment.
- Discuss contaminant fate and transport. This discussion will include potential migration routes, contaminant persistence, and contaminant migration.
- Present a baseline risk assessment. The risk assessment will include human health and environmental evaluations.
- Present a summary and conclusions.

4.2 FEASIBILITY STUDY TASKS

A CMS/FS is planned for the 903 Pad, Mound, and East Trenches Areas to develop and evaluate remedial alternatives for clean up of contaminated soils, ground water, and surface water. Results of the Phase II RFI/RI, including the ARARs analysis and baseline risk assessment will allow development of remediation goals to guide this process.

The CMS/FS process occurs in two phases. The first phase consists of developing and screening remedial alternatives, and the second phase includes a detailed analysis of alternatives (EPA, 1988a). Each of these two phases is discussed in the following sections.

4.2.1 Task 9 - Remedial Alternatives Development and Screening

The goal of this task is to identify and screen remedial alternatives. The work consists of five parts:

- Developing media-specific preliminary remediation goals.
- Identifying and screening remedial technology groups.
- Identifying and screening remedial technology options within each technology group.
- Developing remedial alternatives.
- Screening remedial alternatives.

4.2.1.1 Establish Preliminary Remediation Goals

Preliminary remediation goals will be established early in the FS to support the development and screening of remedial alternatives. Preliminary remediation goals will be applied as performance objectives for evaluating those specific technology processes identified as candidate components of viable remedial action alternatives. Within this context, preliminary remediation goals will be used to perform the following:

- Identify media, areas of the OU, and chemicals requiring remediation. This will be accomplished by comparing, for each affected media, measured or estimated concentrations to preliminary remediation goals.
- 2. Identify the degree of remedial action required for each media. This will be accomplished by comparing, for each affected media, measured or estimated concentrations in areas indicating potential remediation with preliminary remediation goals.

Combining 1 and 2 above provides the basis for estimating the volume of media potentially 3. requiring remediation and for gauging the anticipated chemical or radionuclide concentration

or activity gradient.

Consistent with the NCP (FR 55, No. 46) preliminary remediation goals for carcinogens will be established at

a 1 x 10-8 excess cancer risk point of departure. Preliminary remediation goals may be revised, as the FS

evolves, to a different risk level based on the consideration of appropriate factors including, but not limited to:

exposure, uncertainty, and technical factors.

4.2.1.2 Identify General Response Actions

General response actions that may prove appropriate at the site were identified in Section 2.5. These actions

were identified in order to determine data gaps to be addressed in RI activities. For each response action

potentially applicable remedial technologies were identified. These are also presented in Section 2.5. As the

Phase II RFI/RI progresses, additional potentially applicable technologies will likely be identified.

4.2.1.3 Screening of Technology Types and Process Options

During screening, the broad expanse of potentially applicable technology types will be narrowed by eliminating

those technologies that are not technically implementable. Based on contaminant concentrations and other

site-specific information contained in the Phase II RFI/RI, non-implementable technology types will be screened

and eliminated from further consideration.

Technology process options for each retained technology type will then be screened in order to select a

representative process option for each technology type that is technically implementable. Process options are

compared and eliminated based on their effectiveness relative to other processes within the same technology

type. The screening is based on the volume of media to be treated, achievement of remediation goals,

potential impacts on human health and the environment, and the proven performance and reliability of the

option considering the contaminants and site characteristics. In addition to effectiveness, the process options

will also be evaluated based on administrative feasibility and relative cost. Results of treatability studies and

geotechnical analyses will also be used to evaluate effectiveness, as appropriate.

4.2.1.4 Remedial Alternatives Development and Screening

To develop alternatives, response actions and the process options that are representative of the various

technology types for each medium will be combined to form alternatives for the operable unit. In general, more

than one response action is applicable to each medium. Response actions and process options will be

assembled based primarily on medium-specific considerations and implementability. Descriptions of each alternative will be developed for inclusion in the CMS/FS report.

The response actions outlined in Table 2-17 must be applied to the potential exposure pathways that will be identified for OU No. 2. The response actions can individually be capable of providing control over all or some of the potential pathways. Partially effective response actions can be combined to form complementary sets of response actions that provide control over all pathways. In general terms, potential human exposure may be avoided by prevention of contaminant release, transport, and/or contact. Thus, application of the response actions may be considered at three different points in each potential exposure pathway: (1) at the point where the contaminant could be released from the source, (2) in the transport medium, and (3) at the point where the contact with the released contaminant could be prevented.

During alternative screening, the developed alternatives will be evaluated to ensure that they protect human health and welfare and the environment from each potential pathway of concern at the operable unit. Treatment rates will be identified, and the size and configuration of on-site extraction and treatment systems or containment structures will be developed. The time frame in which treatment, containment or removal can achieve remediation goals will be determined. Lastly, spatial requirements for treatment units, containment structures, staging of construction materials, excavated wastes, etc. will be determined. If there are off-site actions such as surface water discharge, a regulatory review will be conducted to determine permit and compliance requirements. Alternatives will then be evaluated in order to differentiate them with respect to effectiveness, implementability and cost.

Effectiveness is an evaluation of the protectiveness of human health and the environment achieved by a remedial alternative action during construction and implementation, and after the response objectives have been met. Evaluation of effectiveness in the short term is based on protection of the community and workers, impacts to the environment, and the time required to meet remedial response objectives. Long-term evaluation of effectiveness addresses the risk remaining to human health and the environment and is based on the percentage of permanent destruction, decreased mobility, and/or reduction in volume of toxic compounds achieved after response objectives have been met.

Implementability is a measure of both the technical and administrative feasibility of constructing, operating and maintaining a remedial action alternative. It is used during screening to evaluate the combinations of process options with respect to the site-specific conditions. Technical feasibility refers to the ability to construct, reliably operate and comply with action-specific (technology-specific) requirements in order to complete the remedial action. Administrative feasibility refers to the ability to obtain required permits and approvals; to obtain the necessary services and capacity for treatment, storage and disposal of hazardous wastes; and to obtain essential equipment and technical expertise.

Cost estimates for screening will be derived from cost curves, generic unit costs, vendor information, conventional cost estimating guides and prior estimates made for Rocky Flats and similar sites, with modifications made for Rocky Flats Plant conditions. Absolute cost accuracy is not necessary. The cost estimates for the alternatives, however, will have the same relative accuracy for comparison and screening. The cost estimating procedures used during screening are similar to those that will be used during the later detailed alternatives analysis. The later detailed analysis, however, will receive more in-depth and detailed cost estimates of the components of each alternative. The screening cost estimates will include capital, operating, and maintenance costs. The operating and maintenance costs will be calculated for the lifetime of the treatment unit operation at the site. Present worth cost analysis will be used for alternatives in order to make the costs for the various alternatives comparable.

Alternatives with the most favorable results from the composite evaluation will be retained for further scrutiny during the detailed analysis. Not more than 10 alternatives will be retained for detailed analysis (including containment and no action). At that time, it may be determined that additional site-specific information or technology-specific treatability studies are necessary for an objective detailed analysis. Also, it will be necessary to identify and verify the action-specific ARARs that each respective alternative will be required to meet.

4.2.2 Task 10 - Detailed Analysis of Remedial Alternatives

The detailed analysis is not a decision-making process, but it is the process of analyzing and comparing relevant information in order to select a remedial action. Each alternative will be assessed against nine NCP evaluation criteria, and the assessments will be compared to identify the key tradeoffs among the alternatives. Assessment against the nine evaluation criteria is necessary for the CMS/FS and the subsequent Record of Decision (ROD)/Corrective Action Decision (CAD) to comply with the requirements of CERCLA/RCRA. The nine evaluation criteria are described below:

Overall Protection of Human Health and the Environment

The alternatives will be individually analyzed to determine if the alternative provides adequate protection of human health and the environment. The protectiveness evaluation focuses on how the risks posed by each pathway are being eliminated, reduced or controlled by treatment, engineering or institutional measures.

Compliance with ARARs

Each alternative will be analyzed to determine whether it will comply with all state and federal ARARs that have been identified. The analysis will address compliance with chemical-specific, location-specific and action-specific ARARs in accordance with the NCP. If an alternative will not comply with an ARAR, the CMS/FS report will propose a basis for justifying a waiver, if appropriate.

Long-Term Effectiveness and Permanence

This criterion assesses the risks that are left at the site after the response objectives have been met. The risks associated with any remaining untreated wastes or treatment residuals will be evaluated. For each alternative, the magnitude of the residual risk, and the reliability and adequacy of the controls used to manage untreated wastes and treatment residuals will be addressed.

Reduction of Toxicity, Mobility or Volume Through Treatment

This criterion evaluates the statutory preference of selecting remedial actions that permanently reduce toxicity, mobility or volume of the hazardous materials. Factors evaluated for each alternative will include the proposed treatment process and the materials treated; the quantity of materials to be treated or destroyed, and how the primary hazardous threat will be addressed; the estimated degree of the reduction in toxicity, mobility or volume that will be achieved; the extent to which the treatment will be irreversible; the type and quantity of treatment residuals that will remain following treatment; and a determination if the alternative will comply with the statutory preference for treatment.

Short-Term Effectiveness

Short-term effectiveness refers to the effects an alternative may have during the construction and implementation phases until the cleanup objectives have been achieved. Alternatives will be evaluated to determine the effects on human health and the environment during implementation. Each alternative will be assessed against the following factors: protection of the community and workers during the remedial action; environmental impacts; and the time required to achieve the remedial action objectives.

Implementability

This criterion assesses the technical and administrative feasibility of implementing an alternative, and the availability of the necessary services and materials. The following factors will be analyzed during the implementability assessment: the technical feasibility of construction and operation; the reliability of the technology; the practicability of employing additional remedial actions; the ability to monitor the effectiveness of the remedial action; administrative coordination with other offices and agencies; the availability of adequate off-site hazardous (or mixed) waste treatment, storage and disposal; and the availability of equipment, expertise and other services and materials.

Costs

An in-depth cost estimate will be conducted, and, if necessary, a cost sensitivity analysis will be prepared to evaluate costing assumptions. Capital costs include direct construction costs, indirect non-construction costs, and overhead costs. Operating and maintenance costs are incurred after construction in order to operate the remedial action on a continuous basis until the remedial action objectives have been achieved. CMS/FS cost estimates are expected to be within an accuracy range of minus 30 percent to plus 50 percent. If this accuracy cannot be achieved, it will be stated in the CMS/FS report.

A cost sensitivity analysis may be conducted to determine the effect that specific cost assumptions have on the total estimated cost of an alternative. The cost assumptions will be based on site-specific data, technological operating data, etc., although the assumptions will be subject to varying degrees of uncertainty depending on the accuracy of the data.

State Acceptance

This criterion addresses the state's administrative and technical issues and concerns with each of the alternatives.

Community Acceptance

Community acceptance addresses the public's concerns and issues with each of the alternatives.

The CMS/FS report will contain a narrative discussion of each alternatives evaluation against the nine criteria. The narrative will describe how each alternative addresses the technical treatability issues, long-term and short-term effectiveness, costs, protection of human health and the environment, compliance with ARARs, etc. Once the alternatives have been described, a comparative analysis will be conducted to evaluate the relative performance of each alternative. The relative advantages and disadvantages of each alternative with respect to the other alternatives will be determined in order to assess the key tradeoffs that must be made in selecting a remedial action. A candidate alternative must generally attain the primary objectives of compliance with ARARs and overall protection of human health and the environment in order for it to be eligible for selection as the remedial action. A narrative discussion of the alternatives comparison describing the tradeoffs, and the benefits and detriments of each alternative in comparison to the others will be included in the CMS/FS report.

Following completion of the CMS/FS process, the results of the detailed alternatives comparison and risk management will be used as the rationale for selecting a preferred alternative and a remedial action.

4.2.3 Task 11 - Feasibility Study Report

The CMS/FS Report will discuss and present the results of the feasibility study. The results of the detailed alternatives comparison will be used as the rationale for selecting a preferred alternative and a remedial action. Although the purpose of the FS report and process is not to select a remedial action, it will present and evaluate the alternatives in sufficient detail in order to objectively consider all significant issues and select a feasible, cost-effective, and defensible remedial action. The report will include sections describing site background; nature and extent of problem; results of the RFI/RI; risk assessment and environmental evaluation; identification, screening and detailed evaluation of remedial alternatives, and the recommended remedial actions. This task includes preparation of a Draft CMS/FS report, and preparation of a Final CMS/FS that incorporates EPA and CDH comments. A preliminary outline of the CMS/FS report is shown in Table 4-2.

As with the RFI/RI, some portions of the CMS/FS may be conducted separately for the bedrock and alluvial components of the site. It is likely that remediation requirements will not be the same for the bedrock as for

upper HSU. However, both the bedrock and alluvium will be addressed during the CMS/FS and only one CMS/FS report will be prepared.

TABLE 4-2

CMS/FS REPORT FORMAT

Executive Summary

- 1.0 Introduction
 - 1.1 Purpose and Organization of Report
 - 1.2 Background Information (summarized from RI Report)
 - 1.2.1 Site Description
 - 1.2.2 Site History
 - 1.2.3 Nature and Extent of Contamination
 - 1.2.4 Contaminant Fate and Transport
 - 1.2.5 Baseline Risk Assessment
- 2.0 Identification and Screening of Technologies
 - 2.1 Introduction
 - 2.2 Remedial Action Objectives

Present the development of remedial action objectives for each medium of interest (i.e., ground water, soil, surface water, air, etc.).

For each medium, the following should be discussed:

- Contaminants of interest
- Allowable exposure based on risk assessment (including ARARs)
- Development of remediation goals
- 2.3 General Response Actions

For each medium of interest, describes the estimation of areas or volumes to which treatment, containment, or exposure technologies may be applied.

- 2.4 Identification and Screening of Technology Types and Process Options For each medium of interest described
 - 2.4.1 Identification and Screening of Technologies
 - 2.4.2 Evaluation of Technologies and Selection of Representative Technologies
- 3.0 Development and Screening of Alternatives
 - 3.1 Development of Alternatives

Describes rationale for combination of technologies/media into alternatives. Note: This discussion may be by medium or for the site as a whole.

- 3.2 Screening of Alternatives
 - 3.2.1 Introduction
 - 3.2.2 Alternative 1
 - 3.2.2.1 Description
 - 3.2.2.2 Evaluation

Sheet 1 of 2

TABLE 4-2 (Continued)

CMS/FS REPORT FORMAT

- 3.2.3 Alternative 2
 - 3.2.3.1 Description
 - 3.2.3.2 Evaluation
- 3.2.4 Alternative 3
- 4.0 Detailed Analysis of Alternatives
 - 4.1 Introduction
 - 4.2 Individual Analysis of Alternatives
 - 4.2.1 Alternative 1
 - 4.2.1.1 Description
 - 4.2.1.2 Assessment
 - 4.2.2 Alternative 2
 - 4.2.2.1 Description
 - 4.2.2.2 Assessment
 - 4.2.3 Alternative 3
 - 4.3 Comparative Analysis

Bibliography

Appendices

The overall objective of the Phase II RFI/RI is to characterize in detail the nature and extent of soil contamination and plumes within the upper HSU. The specific goals of the RFI/RI (EPA, 1988a) include the following:

- Characterize site physical features.
- Define contaminant sources.
- Describe contaminant fate and transport.
- Provide a baseline risk assessment.
- Provide an adequate body of data for the FS and the ROD.

The purpose of Section 5.0 is to provide a detailed FSP that will realize the goals and the data quality objectives described in Section 3.0. Figure 5-1 presents a flow diagram illustrating the RFI/RI decision process. The necessity for conducting additional investigations will be based on the results obtained from the activities described in this FSP. Subsequent investigations may be required if the newly collected data set does not provide sufficient information to adequately describe the site conceptual model and/or conduct the baseline risk assessment.

5.1 FIELD SAMPLING RATIONALE

A four step approach will be used for the FSP.

- Step One Review of Existing Data
- Step Two Conduct Preliminary and Screening Study Activities
- Step Three Conduct Detailed Field Sampling Program
- Step Four Conduct Field and Analytical Laboratory Testing Programs

5.1.1 Step One - Review of Existing Data

This initial step consists of collecting, reviewing, and analyzing the Phase I RI report, previous drafts of the Phase II work plan, regulatory agency comments on the draft work plans, responses to these comments, and other relevant documents, e.g., data, plans, and reports from adjacent or on-going operable unit investigations. This has been performed in preparation of this work plan. The current understanding of the nature and extent

of contamination at OU No. 2 is based on all available chemical data; however, only data collected through the summer of 1989 are presented. More recent analytical data are not included in this work plan because they are still in the process of being validated and do not significantly alter the site conceptual model. The existing data set also includes an electromagnetic geophysical survey of all the IHSSs (see Phase I RFI/RI Report).

5.1.2 Step Two - Preliminary Field and Screening Study Activities

This second step involves preliminary field and screening study activities in advance of implementing the detailed FSP (Step 3). These include surveying of borehole and IHSS locations, FIDLER monitoring surveys, air monitoring, surface soil and environmental evaluation reconnaissance visits, mobilization for the drilling and sampling program, setting up temporary waste handling facilities, temporary sample storage facilities, and establishment of health and safety procedures. SOPs have been prepared for these activities where appropriate.

5.1.3 Step Three - Detailed Field Sampling Activities

The third step is to conduct detailed field studies that include:

- Plume characterization, well installation, and sampling.
- Source characterization borehole sampling and well installation/sampling.
- Surficial soil sampling.
- Environmental evaluation study.

Sections 5.2, 5.3, and 5.4 describe the details of the first three activities, respectively. The environmental evaluation study is described in Section 6.0. The environmental evaluation will be conducted as an integrated study with the environmental evaluations for OU No. 1, OU No. 5, and OU No. 6. The results relevant to OU No. 2 of this integrated study will be incorporated into the OU No. 2 Phase II RFI/RI Report.

5.1.4 Step Four -- Field and Analytical Tests

This last step includes all of the testing activities (Section 5.5) such as field screening tests for volatile organics and radioactivity, hydraulic pumping and tracer tests, and chemical testing of soil and water samples. All data obtained from these activities will be compiled in the EG&G RFEDS database.

5.2 GROUND-WATER PLUME CHARACTERIZATION PROGRAM

The purpose of the ground-water plume characterization program is to delineate the horizontal and vertical extent

of volatile organic, semi-volatile organic, inorganic, and radiological contaminants in ground water within the upper

HSU. The areal scope of the investigation extends laterally to the seeps within South Walnut Creek and Woman

Creek, and vertically into the Number One Arapahoe Sandstone subcrop. Approximately 64 monitor wells are

proposed for this activity. Monitor wells are proposed for the alluvial and bedrock (weathered bedrock and

subcrop sandstones) systems of the upper HSU.

Presented below are proposed monitor well locations and the rationale for further characterization of ground-water

flow and quality in the upper HSU at OU No. 2 (see Tables 5-1 and 5-2). Bedrock ground-water investigations for

the lower HSU at OU No. 2 are proposed in the Phase II RFI/RI (Bedrock) Work Plan.

Certain well sites have been designated as driver or contingency well sites (Table 5-1 and 5-2, and Plate 1). The

driver well sites will be drilled and completed prior to the drilling and installing of the contingency wells. The

ground-water sample data obtained from the driver wells will be reviewed and evaluated to determine the necessity

for further plume definition. If additional plume characterization is needed, the contingency wells will subsequently

be installed.

The following discussion presents borehole and monitor well locations as if one well will be installed at each

location. However, the number of wells per location and the screened interval of each well will be determined

based upon the saturated thickness. If the encountered saturated thickness is 10 feet or less, a single well will be

installed, and the screened interval will extend from 5 feet above the water table to the base of the water bearing

zone. Two wells will be installed if the saturated thickness is greater than 10 feet and less than 30 feet. One of

the two wells will be completed at the water table as described above, and a second well will be completed across

the lower part of the water bearing unit. If a saturated thickness greater than 30 feet is encountered, a third well

will be completed at the base of the water bearing unit. All plume characterization boreholes for installation of

monitor wells will be drilled, logged, and sampled for lithologic description purposes only. The monitor wells will

be completed in accordance with the Rocky Flats ER Program SOP (EG&G, 1990i). After these plume

characterization monitor wells have been developed, ground-water samples will be collected for analytical chemical

tests on a quarterly basis to record change in the ground-water contamination plume.

Each borehole drilled for monitor well installation for plume characterization will be sampled for volatile organic

compounds (VOCs). The sampling program for boreholes drilled for monitor wells installation in alluvium in

subcropping sandstones are shown in Figures 5-2 and 5-3, respectively. This sampling program consists of

continuous hollow stem auger 2-foot core runs for lithologic logging, and the collection of two discrete samples

per boring for VOC analyses; one at the water table and one at the bedrock claystone contact.

TABLE 5-1

PROPOSED PHASE II WELLS FOR PLUME CHARACTERIZATION

WELL NUMBER	· PURPOSE¹	ANTICIPATED MONITOR WELL TOTAL DEPTH (ft. below g.s)	ANTICIPATED SCREENED INTERVAL
1-91	Volatile organic plume definition downgradient (east) of 903 Pad and Mound Areas.	20	5-20
2-91	Volatile organic plume definition downgradient (east) of 903 Pad and Mound Areas.	20	5-20
3-91	Volatile organic plume definition downgradient (southeast) of 903 Pad and Mound Areas. Extent of saturated colluvium.	10	5-10
4-91	Volatile organic plume definition downgradient (southeast) of 903 Pad. Extent of saturated colluvium.	10	5-10
5-91	Volatile organic plume definition downgradient (southeast) of 903 Pad. Extent of saturated colluvium. Driver well for contingency well 6-91.	10	5-10
6-91	Volatile organic plume definition downgradient (southeast) of 903 Pad. Extent of saturated colluvium. Contingency well based on driver wells 6-91 and 59-91.	10	5-10
7-91	Volatile organic plume definition downgradient (southeast) of 903 Pad. Extent of saturated colluvium. Contingency well based on driver wells 59-91 and 73-91.	10	5-10
8-91	Volatile organic plume definition downgradient (south) of 903 Pad. Extent of saturated colluvium.	15	5-15²
9-91	Volatile organic plume definition downgradient (south) of the 903 Pad Area. Ground water/surface water interaction at	10	5-10
10-91	SID. Volatile organic plume definition downgradient (southeast) of the 903 Pad Area. Ground water/surface water interaction at SID.	15	5-15
11-91	Volatile organic plume definition downgradient (southeast) of the 903 Pad Area.	10	5-10
12-91	Volatile organic plume definition downgradient (southeast) of the 903 Pad Area.	10	5-10
13-91	Ground-water quality upgradient (west) of Operable Unit No. 2.	20	5-20

Sheet 1 of 5

PROPOSED PHASE II WELLS FOR PLUME CHARACTERIZATION

VELL NUMBER	PURPOSE ¹	ANTICIPATED MONITOR WELL TOTAL DEPTH (ft. below g.s)	ANTICIPATED SCREENED INTERVAL
14-91	Ground-water quality and extent of saturation adjacent (south) to possible Pallet Burn Site.	15	5-15
15-91	Ground-water quality downgradient (north) of Pallet Burn Site.	10	5-10
16-91	Ground-water quality downgradient (south) of Oil Burn Pit Site.	10	5-10
17-91	Ground-water quality downgradient (south) of Mound Site.	10	5-10
18-91	Ground-water quality upgradient of Trench T-1 and downgradient of the 903 Pad to differentiate between sources.	15	5-15
19-91	Volatile organic plume definition downgradient (east) of 903 Pad and Mound Areas.	30	5-30 ^{2,4}
20-91	Volatile organic plume definition downgradient (east) of Mound Area.	20	5-20²
21-91	Volatile organic plume definition downgradient (north) of Mound Area.	20	5 - 20
22-91	Volatile organic plume definition downgradient (north) of Mound Area. Driver well for contingency well 25-91.	10	5-10
23-91	Volatile organic plume definition downgradient (northeast) of Mound Area.	15	5-15
24-91	Volatile organic plume definition downgradient (northeast) of Mound Area.	15	5-15
25-91	Volatile organic plume definition downgradient (northeast) of Mound Area. Contingency well based on driver well 22-91.	15	5-15
26-91	Volatile organic plume definition downgradient (northeast) of Mound Area.	25	5-25
27-91	Volatile organic plume definition downgradient (north) of Trench T-3. Replace well 3-74.	10	5-10

Sheet 2 of 5

PROPOSED PHASE II WELLS FOR PLUME CHARACTERIZATION

WELL NUMBER	PURPOSE ¹	ANTICIPATED MONITOR WELL TOTAL DEPTH (ft. below g.s)	ANTICIPATED SCREENED INTERVAL
28-91	Ground-water quality downgradient (east) of Trench T-3 and upgradient (west) of Trench T-4 to differentiate between sources.	10	5-10
29-91	Volatile organic plume definition downgradient (south) of Trench T-3.	15	5-15
30-91	Ground-water quality downgradient (south) of Trench T-4 and upgradient (north) of Trench T-11 to differentiate between sources.	10	5-10³
31-91	Ground-water quality downgradient (south of Trench T-4) and upgradient (north) Trench T-10 to differentiate between sources.	20	5-20
32-91	Volatile organic plume definition downgradient (east) of Trench T-10.	30	5-30²
33-91	Volatile organic plume definition and extent of saturation downgradient (north) of East Trenches Area. Driver well for contingency well 36-91.	10	5-10
34-91	Volatile organic plume definition and extent of saturation downgradient (north) of East Trenches Area.	10	5-10
35-91	Volatile organic plume definition and extent of saturation downgradient (north) of East Trenches Area.	30	5-30
36-91	Volatile organic plume definition and extent of saturation downgradient (north) of East Trenches Area. Contingency well based on driver wells 33-91 and 37-91.	10	5-10
37-91	Volatile organic plume definition and extent of saturation downgradient (north) of East Trenches Area. Driver well for contingency well 36-91.	10	5-10
38-91	Volatile organic plume definition and extent of saturation downgradient (north) of East Trenches Area.	20	5-20
39-91	Volatile organic plume definition and extent of saturation downgradient (north) of East Trenches Area. Contingency well based on driver well 56-91.	25	5-25
40-91	Volatile organic plume definition and extent of saturation downgradient (northeast) of East Trenches Area. Contingency well based on driver well 56-91.	10	5-10
41-91	Ground-water quality upgradient (west) of southern East Trenches.	30	5-30

PROPOSED PHASE II WELLS FOR PLUME CHARACTERIZATION

WELL NUMBER	PURPOSE ¹	ANTICIPATED MONITOR WELL TOTAL DEPTH (ft. below g.s)	ANTICIPATED SCREENED INTERVAL
42-91	Ground-water quality downgradient (south) of Trench T-9.	20	5-20
43-91	Ground-water quality downgradient (east) of Trenches T-5, T-6, and T-7. Evaluate influence of East Spray Field Sites on ground-water flow and quality.	40	5-405
44-91	Volatile organic plume definition downgradient (southeast) of East Trenches Area.	30	5 - 30
45-91	Volatile organic plume definition downgradient (southeast) of East Trenches Area. Driver well for contingency well 54-91.	50	5-40
46-91	Volatile organic plume definition downgradient (southeast) of East Trenches Area. Driver well for contingency wells 47-91 and 54-91.	50	5-50
47-91	Volatile organic plume definition downgradient (southeast) of East Trenches Area. Contingency well based on driver well 46-91.	50	5-50
48-91	Evaluate influence of East Spray Field Sites on ground-water flow and quality. Driver well for contingency wells 54-91 and 57-91.	40	5-40
49-91	Evaluate influence of East Spray Field Sites on ground-water flow and quality. Driver well for contingency well 57-91.	. 35	5-35
50-91	Evaluate influence of East Spray Field Sites on ground-water flow and quality. Driver well for continency well 58-91.	35	5-35
51-91	Evaluate influence of East Spray Field Sites on ground-water flow and quality.	35	5-35
52-91	Evaluate influence of East Spray Field Sites on ground-water flow and quality.	40	5-40
53-91	Volatile organic plume definition and extent of saturation downgradient (north) of East Trenches Area.	35	5-35
54-91	Ground-water quality southeast of East Trenches Area. Contingency well based on driver wells 45-91, 46-91, and 48-91.	10	5-10
55-91	Volatile organic plume definition downgradient (south) of 903 Pad Area. Contingency well based on driver well 73-91.	10	5-10
56-91	Ground-water quality downgradient (northeast) of Trench T-4. Driver well for contingency well 39-91.	10	5-10

PROPOSED PHASE II WELLS FOR PLUME CHARACTERIZATION

WELL MANBER	PURPOSE ¹	ANTICIPATED MONITOR WELL TOTAL DEPTH (ft. below g.s)	ANTICIPATED SCREENED INTERVAL
57-91	Ground-water quality downgradient (east) of East Trenches. Contingency well based on driver well 48-91 and 49-91.	40	5-40
58-91	Ground-water quality downgradient (east) of East Trenches. Contingency well based on driver well 50-91.	40	5-40
59-91	Ground-water quality downgradient (southeast) of 903 Pad and Reactive Metal Destruction Site. Driver well for contingency well 6-91 and 7-91.	10	~ 5-10
60-91	Ground-water quality downgradient (northeast) of East Trenches Area	35	5-35
61-91	Ground-water quality downgradient (northeast) of East Trenches Area	40	5-40
62-91	Volatile organic plume definition and extent of saturation downgradient (northeast) of East Trenches Area	25	5-25
63-91	Volatile organic plume definition and extent of saturation downgradient (northeast) of East Trenches Area	30	5-30
64-91	Volatile organic plume definition and extent of saturation downgradient (northeast) of East Trenches Area	10	5-10

Notes:

Ground-water quality and lithologic data will provide better characterization of the ground-water exposure pathway in support of the baseline risk assessment.

Plume Characterization

g.s. ground surface

Sheet 5 of 5

If the encountered saturated thickness is greater than 10 feet, a well cluster will be installed as explained in Section 5.1.1.

This is the site for T-1 Hydraulic Test (Case 1) - 4 additional wells.

This is the site for I-2 Hydraulic Test (Case 2) - 9 additional wells.

This is the site for T-3 Hydraulic Test (Case 3) - 4 additional wells.

TABLE 5-2

PROPOSED PHASE II WELLS AND BOREHOLES FOR SOURCE CHARACTERIZATION

WELL/BOREHOLE Mumber	PURPOSE ¹	ANTICIPATED MONITOR WELL TOTAL DEPTH (ft. below g.s)	ANTICIPATED SCREENED INTERVA
65-91/ВН0191	Characterization upgradient (west) of 903 Pad.	10	5-10
вн0291	Source characterization 903 Pad.	N/A	N/A
66-91/BH0391	Ground-water quality beneath 903 Pad. Source characterization 903 Pad.	15	5-15
BH0491	Source characterization 903 Pad.	N/A	N/A
67-91/BH0591	Ground-water quality downgradient (south) of 903 Pad. Soil characterization adjacent to 903 Pad ³ .	15	5 - 15
68-91/BH0691	Ground-water quality downgradient (north) of 903 Pad. Soil characterization adjacent to 903 Pad.	. 10	5-10
вн0791	Source characterization 903 Pad.	. N/A	N/A
BH0891	Source characterization 903 Pad.	N/A	N/A
вн0991	Source characterization 903 Pad.	N/A	N/A
BH1091	Source characterization 903 Pad.	N/A	N/A
69-91/BH1191	Ground-water quality downgradient (east) of 903 Pad. Soil characterization adjacent to 903 Pad.	10	5-10
70-91/BH1291	Ground-water quality downgradient (east) of 903 Pad. Soil characterization adjacent to 903 Pad.	10	5-10
71-91/BH1391	Ground-water quality downgradient (south) of 903 Pad. Soil characterization adjacent to 903 Pad.	10	5-10
BH1491	Source characterization Trench T-2.	N/A	N/A
ВН1591	Source characterization Trench T-2. Extent of soil contamination.	N/A	N/A
72-91/BH1691	Ground-water quality downgradient (south) of 903 Pad and upgradient of Trench T-2 (north) to differentiate between sources.	10	5-10
BH1791	Source characterization Trench T-2. Extent of soil contamination.	N/A	N/A
Вн1891	Source characterization Trench T-2. Extent of soil contamination.	N/A ·	N/A
73-91/BH1991	Ground-water quality downgradient (south) of Trench T-2. Extent of soil contamination. Driver well for contingency well 7-91 and 55-91.	10	5-10

Sheet 1 of 3

PROPOSED PHASE II ALLUVIAL WELLS AND BOREHOLES FOR SOURCE CHARACTERIZATION

MELL/BOREHOLE NUMBER	PURPOSE'	ANTICIPATED MONITOR WELL TOTAL DEPTH (ft. below g.s)	ANTICIPATED SCREENED INTERVAL
74-91/BH2091	Source characterization Reactive Metal	10	5-10
	Destruction Site.	•	
75-91/BH2191	Ground-water quality downgradient (south) of Reactive Metal Destruction Site.	10	5-10
ВН2291	Source characterization Reactive Metal Destruction Site.	N/A	N/A
76-91/BH2391	Ground-water quality downgradient of Reactive Metal Destruction Site. Extent of soil contamination.	1Ó	5-10
BH2491	Extent of soil contamination.	N/A	N/A
77-91/BH2591	Ground-water quality beneath Mound Site. Source characterization.	10	5-10
BH2691	Source characterization.	N/A	N/A
вн2791	Extent of soil contamination Mound Site.	N/A	N/A
Вн2891	Investigation possible Pallet Burn Site location.	N/A	N/A
BH2991	Source characterization.	H/A	N/A
вн3091	Source characterization.	N/A	N/A
вн3191	Source characterization.	N/A	N/A
78-91/BH3291 ·	Ground-water quality beneath Trench T-11. Source characterization.	25	10-25
вн3391	Source characterization.	N/A	N/A
79-91/BH3491	Ground-water quality beneath Trench T-9. Source characterization.	25	5-25
80-91/BH3591	Ground-water quality beneath Trench T-5. Source characterization.	20	5-20
81-91/BH3691	Ground-water quality beneath Trench T-5. Source characterization.	15	5-15

Sheet 2 of 3

PROPOSED PHASE II ALLUVIAL WELLS AND BOREHOLES FOR SOURCE CHARACTERIZATION

ÆLL/BOREHOLE Number	PURPOSE ¹	ANTICIPATED MONITOR WELL TOTAL DEPTH (ft. below g.s)	ANTICIPATED SCREENED INTERVAL	
вн3791	Source characterization.	N/A	N/A	
82-91/BH3891	Ground-water quality beneath Trench T-7. Source characterization.	20	5-20	
83-91/BH3991	Ground-water quality beneath Trench T-7. Source characterization.	20	5-20	
34-91/BH4091	Ground-water quality beneath Trench T-8. Source characterization.	20	5-20	
5-91/8H4191	Ground-water quality beneath Trench T-8. Source characterization	20	5-20	
BH4291	Source characterization.	N/A	N/A	
вн4391	Ground-water quality beneath the East Spray Field. Source characterization.	N/A	N/A	
BH4491	Source characterization.	. N/A	N/A	
BH4591	Source characterization.	N/A	N/A	
ВН4691	Source characterization.	N/A	N/A	
		Total Proposed Boreholes Total Proposed Monitor Wells for Source Characterization	= 21	
		Total Drill Sites for Source Characterization	= 67	
		Total Drill Sites for Source and Plume Characteria	= 131 zation	

Notes:

Ground-water and soil analyses will be used to define the range and maximum concentration of contamination in support of the baseline risk assessment.

g.s. ground surface

Sheet 3 of 3

If the encountered saturated thickness is greater than 10 feet, a well cluster will be installed as explained in Section 5.1.1

In the context of source characterization, the term "Soil" means alluvial and/or weathered bedrock materials.

TYPICAL BOREHOLE FOR PLUME CHARACTERIZATION MONITOR WELL INSTALLATION IN ALLUVIUM

GROUND SURFACE CT CT CT CT **ALLUMUM** CT CT CT HOLLOW STEM AUGER 2-FOOT CONTINUOUS STATIC WATER CT CORE RUNS CT CT CLAYSTONE CT **BEDROCK** 6 FEET CT CT

LEGEND

СТ

2-FOOT CONTINUOUS HOLLOW STEM AUGER CORE RUN

DISCRETE 2-FOOT LABORATORY SAMPLE FOR VOLATILE ORGANIC ANALYSIS U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLIVIAL)

LITHOLOGIC AND CHEMICAL SAMPLING FOR PLUME CHARACTERIZATION MONITOR WELL BOREHOLES IN ALLUVIUM

FIGURE 5-2

August, 1991

August, 1991

5.2.1 Proposed Borehole and Monitor Wells in Alluvium

Boreholes and monitor wells are proposed for each of the following IHSS Areas. Tables 5-1 and 5-2 include a more detailed summary of each borehole and monitor well, and drilling locations are shown on Plate 1.

903 Pad Area - 26 wells

Mound Area - 15 wells

East Trenches Area - 44 wells

5.2.1.1 903 Pad Area

Fourteen proposed alluvial monitor wells will further define the lateral extent of saturation, the potentiometric surface, and the extent volatile organics in the shallow ground-water system east and southeast of the 903 Pad Area (Plate 1). Two wells (1-91 and 2-91) will be completed in Rocky Flats Alluvium east of the 903 Drum Storage Site to define the extent of volatile organics in alluvial ground water and to characterize alluvial ground-water flow. Likewise, 10 alluvial wells (3-91 through 8-91, 11-91, 12-91, 55-91, and 59-91) will be completed in colluvium south and southeast of the 903 Pad Area for plume delineation. Wells 5-91, 59-91, and 73-91 are driver wells that will be used to evaluate the need for contingency wells 6-91, 7-91, and 55-91. Alluvial wells 9-91 and 10-91 will be drilled along the northern berm of the SID and completed in the berm to monitor the quality of ground water adjacent to the ditch.

5.2.1.2 Mound Area

Several new alluvial monitor wells are proposed for the Mound Area. The current upgradient well (43-86) appears to be impacted by the 903 Drum Storage Site, so another upgradient alluvial well is needed. Proposed well 13-91 will be installed in Rocky Flats Alluvium west of 43-86 and the 903 Pad Area to serve as an upgradient well.

Four wells will be located downgradient of the Oil Burn Pit No. 2 Site and the Pallet Burn Site to monitor ground water from these sites. As these IHSSs are within the PA fence, well installation downgradient of them is difficult. Wells will be placed as close as possible to the IHSSs. Well 14-91 will be installed adjacent to the Western Pallet Burn Site, and wells 15-91 and 16-91 will be installed downgradient of this site inside the PA fence. Well 17-91 will be installed downgradient of the Oil Burn Pit No. 2 Site, outside of the PA fence.

Nine wells will be located downgradient of Trench T-1 and the Mound Site. Well 18-91 will be installed adjacent to and downgradient of Trench T-1. In addition, two wells (19-91 and 20-91) will be installed downgradient of the Mound Site and Trench T-1 to the east, to evaluate the extent of volatile organic contamination in this

direction. Six wells (21-91 through 26-91) will be completed north and northeast of the Mound Area to characterize ground-water flow and quality toward South Walnut Creek. Well 22-91 will serve as a driver well for contingency well 25-91.

5.2.1.3 East Trenches Area

Six new alluvial wells will be drilled within the northern trench area to characterize ground-water quality and flow. Wells 27-91, 28-91, and 29-91 will be installed downgradient of Trench T-3 to the north, east, and south, respectively. These proposed wells will assist in differentiating between Trenches T-3 and T-4 as the source of volatile organics in well 36-87. Wells 30-91 and 31-91 will be constructed between Trenches T-3/T-4 and T-11/T-10 in an attempt to differentiate the two groups of trenches as contaminant sources. Alluvial ground-water flow in this area is to the southeast toward Trenches T-10 and T-11. Well 32-91 will be located east of Trench T-10 to further characterize the extent of volatile organics in alluvial ground water.

Downgradient of the northern East Trenches toward South Walnut Creek, nine new wells will be installed to evaluate saturated conditions and to delineate the plume north of the trenches (proposed wells 33-91 through 40-91 and 56-91). Proposed wells 33-91 and 37-91 will serve as the driver wells for contingency well 36-91. In addition, the need for contingency wells 39-91 and 40-91 will be evaluated based on the results from driver well 56-91. Five new alluvial wells will be installed downgradient (northeast) of the East Trenches. These wells will be used to investigate the ground-water volatile organic contamination apparently present in the vicinity of well 39-86 (unvalidated). Wells 60-91 and 61-91 will be located upgradient of existing well 39-86 and downgradient of the East Trenches to aid in determining the source of the contamination. Proposed wells 62-91 and 63-91 will be installed immediately downgradient of well 39-86, and well 64-91 will be installed in valley fill alluvium at the plant boundary to better define the extent of contamination.

Three new alluvial wells are proposed within the southern trenches, again, to help differentiate between these potential contaminant sources and define the extent of contamination and pathways within the upper HSU. Well 41-91 will be installed south of the northern trenches and west of the southern trenches to differentiate between these source areas. Well 42-91 will be drilled adjacent to Trench T-9, and well 43-91 will monitor flow out of Trenches T-5, T-6, and T-7.

Thirteen alluvial wells will be installed surrounding the southern East Trenches and the East Spray Field to monitor flow and quality of ground water exiting the area. These wells (44-91 through 53-91, 57-91, and 58-91) will help delineate the southern and eastern extent of volatile organics plumes in Rocky Flats alluvial ground water. Well 54-91 will be located south of this line of wells and will be completed in colluvium to further characterize hydrogeologic conditions in this area. Proposed wells 45-91, 46-91, 48-91, 49-91, and 50-91 will serve as driver wells for contingency wells 54-91, 47-91 and 54-91, 54-91 and 57-91, and 58-91 (Table 5-1).

5.2.2 Proposed Monitor Wells in Bedrock

Arapahoe sandstones, which subcrop within OU No. 2, are in hydraulic connection with surficial materials and are thus part of the upper HSU (Figure 2-15). During previous investigations, bedrock monitoring wells were installed adjacent to alluvial wells in the uppermost sandstone encountered. Some of these wells are completed in subcropping sandstone, and volatile organic contaminants have been detected in some wells as discussed in Section 2.0. In order to further characterize ground-water flow directions and ground-water quality within these shallow sandstones, additional bedrock monitor wells will be installed during the Phase II RFI/RI. The deeper confined bedrock units will be investigated during implementation of the Phase II (Bedrock) work plan. The interface between the alluvial and the bedrock field investigations is shown in Figure 1-1.

The placement of bedrock monitor wells in the upper HSU will be based on conditions encountered during alluvial well drilling. Alluvial wells will be drilled 6 feet into bedrock to locate subcropping sandstones. If a saturated subcropping sandstone greater than 3 feet in thickness is encountered within this 6-foot interval, surface casing will be set, the boring will be advanced through the sandstone and a minimum of 6 feet into claystone or siltstone beneath the upper sandstone layer. A bedrock well will then be completed within this upper sandstone layer. A second boring will then be drilled adjacent to the bedrock well for installation of an alluvial well.

5.3 SOURCE CHARACTERIZATION PROGRAM

Boreholes will be drilled into IHSSs where access is feasible in order to characterize any waste materials remaining in place, and to assess the maximum contaminant concentrations in the alluvium and weathered bedrock directly beneath the sites. In addition, ground-water monitoring wells will be installed within selected boreholes to characterize ground-water quality directly beneath the sites. This section discusses those selected wells and boreholes which will be drilled for source characterization. Wells to be drilled outside of IHSSs for characterizing the extent of plume contamination are discussed in Section 5.2. Table 5-2 provides an overview of all proposed Phase II RFI/RI source characterization boreholes and wells which are shown on Plate 1. All drilling, sampling, and well installation will follow the Rocky Flats Plant ER Program SOP.

Boreholes to be drilled into IHSSs will extend from the ground surface to 6 feet below the base of alluvial material if no sandstone is encountered. Continuous borehole samples will be collected for lithologic descriptions for the entire borehole depth. From this core, discrete samples will be submitted for laboratory volatile organic compound (VOC) analyses beginning 2 feet below the ground surface, continuing at a frequency of one sample per 4-foot interval to the water table. A sample for volatile organic analysis will also

be collected from the bottom of the first drive sample below the water table. In addition, a discrete sample will be collected for volatile organic analysis if staining, discoloration, odor, or other anomaly is observed during drilling. Core from saturated alluvial materials will not be submitted to the laboratory as the presence of water in this zone will affect interpretation of chemical results. A final VOC sample will be collected for chemical analysis from the base of the first drive within bedrock immediately below the alluvial material. If drilling is to continue below the standard 6 feet into bedrock (i.e., if a sandstone is encountered), surface casing will be grouted into the borehole through alluvial materials. Samples selected from the core will be submitted to the laboratory for chemical analysis in addition to the VOC analysis. These samples will be composites of each 6-foot interval drilling and sampling. If a sandstone is encountered, the composite sampling will be collected to approximately 6 feet into claystone bedrock. In addition, a sample for VOC analysis will be collected from the top of the sandstone and the claystone units. Details of this sampling are found in SOP GT2, Sampling Procedure 5.3. Figures 5-4 and 5-5 illustrate the typical sampling and testing scheme for boreholes drilled in alluvial materials and subcropping sandstones, respectively.

Alluvial and bedrock ground-water monitoring wells will also be installed in reconditioned boreholes to characterize ground-water quality directly beneath IHSSs. Wells will be drilled, sampled, and completed in accordance with the Rocky Flats ER Program SOP.

The screened interval of all alluvial and bedrock monitor wells will depend on the saturated thickness. If the saturated thickness is 10 feet or less, a single well will be installed and the screened interval will extend from 5 feet above the water table to the base of the water-bearing zone. Two wells will be installed if the saturated thickness is greater than 10 feet and less then 30 feet. One of the two wells will be completed at the water table as described above, and a second well will be completed across the lower part of the water bearing unit. If a saturated thickness greater than 30 feet is encountered, a third well will be completed at the base of the water bearing unit. In addition, a bedrock well will be installed if a subcropping sandstone is encountered. Source characterization well locations are discussed in the following sections.

5.3.1. 903 Pad Area

IHSSs of the 903 Pad Area are shown in Figure 1-5. Specific source sampling activities for sites within the 903 Pad Area are discussed below for the 903 Drum Storage Site, 903 Lip Site, Trench T-2 Reactive Metal Destruction Site, and Gas Detoxification Site.

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903 Drum Storage Site (IHSS Ref. No. 112)

In order to characterize the vertical and horizontal extent of radionuclide and solvent contamination beneath

the 903 Pad, 13 boreholes (BH0191 through BH1391) are proposed within and immediately adjacent to the site.

These boreholes have been located in areas which contained drums as well as in areas which historically did

not contain drums (Figure 5-6). In order to characterize the ground water beneath and adjacent to the 903

Pad, alluvial monitoring wells 65-91 through 71-91 will be installed in boreholes BH0191, BH0391, BH0591,

BH0691, BH1191, BH1291, and BH1391, respectively.

903 Lip Site (IHSS Ref. No. 155)

Boreholes will not be drilled specifically for source characterization of the 903 Lip Site as surficial radionuclides

are the contaminants of concern. Therefore, surficial soil sampling and radionuclide analyses will be

performed in the area. This sampling is discussed in Section 5.4.

Trench T-2 Site (IHSS Ref. No. 109)

One borehole (BH1491) will be drilled through the east end of Trench T-2 to characterize the contents and

dimensions of the site (Plate 1). Barrels are known to be present at the west end of the trench, so no borehole

will be drilled in this area.

Boreholes BH1591, BH1691, BH1791, BH1891, and BH1991 will be drilled around Trench T-2 to verify its

location and to evaluate the extent of soil contamination in the area. Colluvial monitoring wells 72-91 and 73-91

will be installed within boreholes BH1691 and BH1991, respectively, to monitor water quality upgradient and

downgradient of Trench T-2. In addition, well 73-91 will serve as a driver well for contingency wells 7-91 and

55-91.

Reactive Metal Destruction Site (IHSS Ref. No. 140)

Three boreholes (BH2091, BH2191, and BH2291) will be drilled within the Reactive Metal Destruction Site to

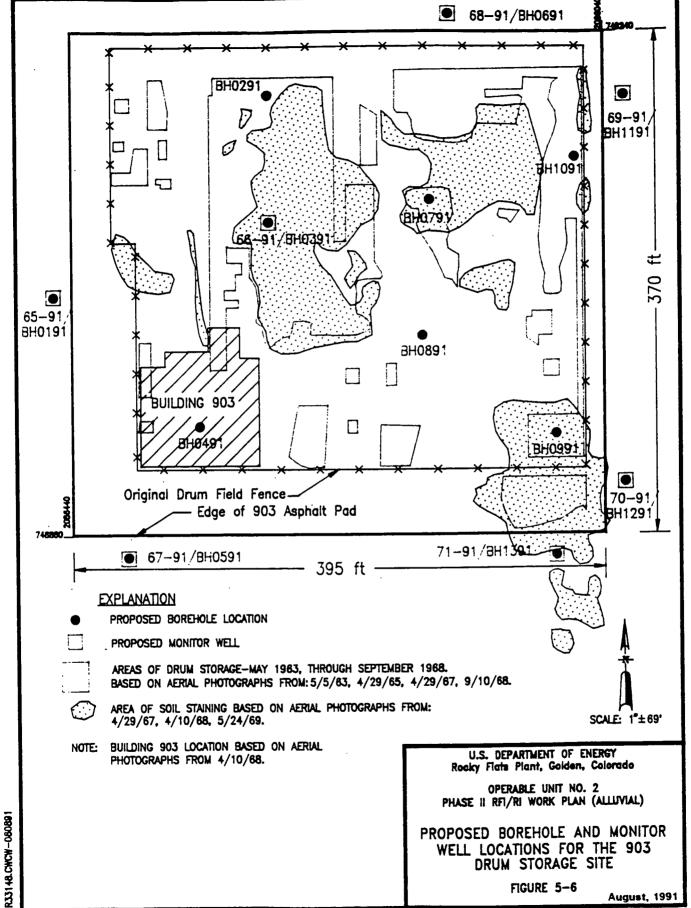
further characterize this source and the extent of soil contamination. Boreholes BH2391 and BH2491,

downgradient of the site, will be drilled and sampled to evaluate the extent of soil contamination in the area.

Colluvial monitoring wells 74-91 through 76-91 will be completed within boreholes BH2091, BH2191, and

BH2391, respectively, to monitor water quality within and downgradient of the site (Plate 1).

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Gas Detoxification Site (IHSS Ref. No. 183)

A boring (BH4691) will be drilled within the Gas Detoxification Site. This borehole is designed to characterize

the potential source.

5.3.2 Mound Area

IHSSs within the Mound Area are identified on Figure 1-5. Proposed well and borehole locations are shown

on Plate 1 and summarized in Table 5-2. Details of source characterization activities planned for sites within

the Mound Area are provided below. These include the Mound Site, Trench T-1, Oil Burn Pit, and the Pallet

Burn Site.

Mound Site (IHSS Ref. No. 113)

Boreholes BH2591 and BH2691, are proposed within the revised boundaries of the Mound Site to characterize

soils and any remaining wastes. Alluvial monitoring well 77-91 will be completed in borehole BH2591 to

monitor ground-water quality beneath the site. In addition, borehole BH2791 will be drilled and sampled

downgradient of the Mound Site adjacent to existing wells 1-74 and 19-87. This hole will serve to characterize

the nature and extent of soil contamination possibly associated with the high levels of PCE and TCE detected

in well 1-74.

Trench T-1 Site (IHSS Ref. No. 108)

No boreholes are proposed within Trench T-1 because of the ubiquitous presence of barrels. However,

additional alluvial ground-water monitoring wells are proposed adjacent to the trench as discussed in Section

5.2.1.2.

Oil Burn Pit No. 2 Site (IHSS Ref. No. 153)

This site was removed in the 1970s and its location is currently covered by the PA fence which is inaccessible

for security purposes. Therefore, no additional boreholes are proposed for source characterization of this site.

Additional monitor wells upgradient and downgradient of the Oil Burn Pit Site are discussed in Section 5.2.1.2.

Pallet Burn Site (SWMU Ref. No. 154)

The western-most of the two possible locations for this site is located within the PA fence. As this area is

inaccessible and boreholes were drilled adjacent to this site during the Phase I RI, no additional boreholes are

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proposed. However, an additional borehole (BH2891) will be drilled in the possible eastern location of the

Pallet Burn Site identified from historical aerial photographs. This borehole will aid in verifying the location of

IHSS 154.

5.3.3 East Trenches Area

IHSSs within the East Trenches Area that will be investigated as part of this source characterization study

include Trenches T-3 to T-11 and the two East Spray Fields.

Trenches T-3 Through T-11 (IHSS Ref. Nos. 110, 111.1 through 111.8)

As shown in Figure 1-5, IHSSs within the East Trenches are closely spaced and portions of the trenches are

occupied by barrels. Location of boreholes and monitoring wells are presented in Plate 1 and summarized

on Table 5-2.

The boreholes proposed within the East Trenches are located in portions of the trenches devoid of barrels.

Boreholes within the trenches will not only provide waste and source characterization, but also details on the

construction of the trenches. Alluvial monitoring wells will be completed in all of the boreholes. These

sampling locations are discussed below.

Five boreholes will be drilled through the northern trenches in areas not containing barrels. Borehole BH2991

will be drilled through the western end of Trench T-3 which is devoid of barrels, and boreholes BH3091 and

BH3191 will be drilled through Trench T-4. Boreholes BH3291 and BH3391 will be drilled at the ends of Trench

T-11 outside of the area containing barrels. Trench T-10 is filled with barrels; therefore, no boreholes will be

drilled into this IHSS. An alluvial monitoring well will be completed in borehole BH3291 (well 78-91).

Nine boreholes (BH3491 through BH4191) will be drilled and sampled in portions of the southern trenches

devoid of barrels (Table 5-2). Several of these boreholes will have alluvial monitoring wells (79-91 through

85-91) completed in them to characterize alluvial ground-water quality immediately beneath the sites.

East Spray Field (IHSS Ref. Nos. 216.2 and 216.3)

Four boreholes, BH4291 through BH4591, are proposed within the boundaries of the East Spray Field. The

data obtained from these boreholes will be used to characterize the soils in the East Spray Field.

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5.4 SURFICIAL SOILS SAMPLING PROGRAM

The contamination of surficial soils around Rocky Flats Plant by plutonium (Pu) oxides was mainly caused by leaking barrels of plutonium-contaminated oil in the area known as the 903 Pad (Krey and Hardy, 1970). Numerous studies (Krey and Hardy, 1970; Seed, et al., 1971; Poet and Martell, 1972; Johnson, et al., 1976; Little, 1980; Little, et al., 1980) concluded that surficial soils in the area east of the 903 Pad are contaminated with plutonium and americium (Am) due to wind dispersal of soil particles during cleanup operations. More recently, the Phase I RI of the OU No. 2 (Rockwell International, 1987a) found that the concentrations of plutonium and americium were elevated in composite soil samples adjacent to Trench T-2 (BH25-87, BH26-87, and BH27-87) and the Reactive Metal Destruction Site (BH28-87) T-1 (boreholes BH35-87 and BH36-87). In addition, the Phase I RI found occasional elevated concentrations of plutonium (> 0.05 pCi/l) in filtered and unfiltered surface water samples from seeps (SW-50, SW-53, and SW-54) and in stream sediments (> 0.9 pCi/g) along Woman Creek (SED-25, SED-26, SED-29, and SED-30). It has been suggested that the source of the contaminated sediments is the surface soils from the 903 Pad Area that are transported by wind. However, the elevated concentrations of plutonium in filtered and unfiltered seep waters above Woman Creek suggest that some of the plutonium may travel in surface and ground water. Also, soil sampling results indicate that the actinides are enriched near the ground surface. Further investigation is necessary to characterize the transport mechanisms that control the spatial and vertical distribution of these radionuclides.

The objectives of the proposed work plan for the surficial soils are: to determine the spatial and vertical extent of plutonium and americium in soils of the remedial investigation areas, and in the buffer zone; to study the physicochemical association of plutonium and americium in surficial soils (static and mobile soil phases) above seeps SW-50, SW-53, and SW-54; to study the movement of both water and radionuclides (colloidal and dissolved) down the soil column; and, to ascertain the hydrogeochemical relationships between the soil interstitial water and the seeps downslope. A detailed sampling plan for surficial soils is provided in Attachment 1.0.

5.4.1 Spatial Distribution - Sampling

In order to assess the extent of plutonium and americium in surficial soils within the plant boundaries, soil samples will be collected across the area identified in Figures 5-7 and 5-8 consisting of approximately 800 acres. Figures 5-7 and 5-8 were constructed based on review of previous investigation results, data analysis of unpublished material, and radiological surveys. The geostatistical analysis of previous investigation results are presented in the surficial soil sampling plan (Attachment 1.0). The State of Colorado requires special techniques for construction on lands with plutonium concentrations greater than 0.9 pCi/g of dry soil. To evaluate the soil-plutonium values relative to this guideline, the CDH sampling protocol will be used.

The CDH sampling protocol requires 25 subsamples to be composited within a 10-acre area for plutonium and americium analysis. Because of the large variations in soil-plutonium near the source area, a 2.5-acre grid will be sampled immediately east of the 903 Pad and around the East Trenches Area (Figure 5-8). This sampling design will serve two purposes: (1) to increase the confidence in soil-plutonium estimates around the 903 Pad and East Trenches Areas; and, (2) to expand the number of soil data for kriging estimates. The soil sampling in the 2.5-acre areas will consist of 25 subsamples for plutonium and americium determination. The soil sampling in the 10-acre grid areas will also consist of 25 subsamples for plutonium and americium determination. The northwest corner of each grid will be surveyed and identified with an appropriately marked steel post. Grids will be oriented on the cardinal compass directions. The 25 subsamples for each composite sample will be located with a hand held compass and tape measure using the northwest corner as the starting point. Additional 10-acre plots will be added if large concentrations of plutonium and americium are detected north of the Mound Area.

5.4.2 Vertical Distribution - Sampling

Twenty-six soil profiles will be excavated, described, and sampled in order to assess the vertical distribution of plutonium-239,240 and americium-241 in soils east and south of the Rocky Flats Plant. Eleven soil profiles will be excavated in the immediate vicinity of the 903 Pad, East Trenches, and seep SW-53, and an additional 12 soil profiles will be excavated according to soil types, direction, and distance from the 903 Pad. Three additional profiles will be located in the OU No. 1 study area. The approximate locations for the proposed soil profiles are depicted in Figure 5-8. The soil profiles will be dug in undisturbed or the least disturbed sites which are characterized by the natural short grass prairie, pasture, and valley side vegetation (Clark, et al., 1980). The exact location of the soil profiles will be determined in the field using aerial photographs, soil and topographic maps, radiological surveys, and common sense. Transport of soil-plutonium in the soil environment is highly affected by soil type, moisture content, texture, structure, and particle characteristics such as shape, density, and cohesiveness (Burley, 1990). Hence, all the major soil types east of the 903 Pad (Table 2-2) will be sampled.

Surficial soil samples from the 26 soil profiles will be collected using a modified trench method (Harley, 1972). This method involves digging a trench with a backhoe or shovel 1.5 meters long, 1.0 meter wide and 1.0 meter deep. One wall of the trench will be dug as a block/stair case (15 centimeter height each) to minimize cross contamination. The vegetation at the surface of the selected wall will be cropped closely to the surface and discarded. The soil morphology will be described according to the standard operating procedures for logging alluvial and bedrock material (SOP 3.1, EG&G 1990i). The soil will be sampled at intervals of 3 centimeters starting at the deepest block/stair in a given pit. Soil samples will be collected using a stainless steel scoop and template (3 centimeters x 20 centimeters) which will be pressed into the wall of the block/stair case. Three samples from each depth will be consolidated to provide a better representation of the site and to produce

enough soil material for the various chemical analyses described in the following sections. After a sample has been collected, the soil layers below it will be cleared of sloughed material to prevent possible contamination from the upper soil layers. A flag will be placed on the ground surface of a given pit and the depth below surface for each sample will be measured from the base of the flag. Each pit will be backfilled with the original soil mixture removed during the excavation.

5.4.3 Static Phase Physicochemical Association of Plutonium and Americium

The physicochemical association of plutonium and americium in the soils east of the 903 Pad will be studied using a sequential extraction methodology. The soils will be extracted into four major physicochemical fractions -- carbonates, organics, sesquioxides, and residues. This partitioning is described below (Static Soil Phase -- Proposed Work) and Attachment 1.0. Transport mechanisms of actinides in the soil profile will also be evaluated (mobile soil phase). Methods used to determine these leaching mechanisms include the collection of soil interstitial water and surface runoff water, recording precipitation events, and hydrologic rain model simulation. These methods are described in Section 5.4.4 and in Attachment 1.0.

5.4.3.1 Static Soil Phase - Proposed Work

Plutonium determination in the static soil phase will be performed on four sequential selective extracts in triplicates to assess the physicochemical association of plutonium. This is accomplished by partitioning each pedologic sample into the four fractions described below: calcium carbonate (CaCO₃), organic carbon (C), sesquioxides, and residue (Figure 1-10 of Attachment 1.0). In this study of the static soil phase, the gamma emitting isotope plutonium-237 will be used as a tracer to assess the degree of post-extraction readsorption of plutonium isotopes (plutonium-239,240) during the various extractions performed on the soils. In addition, the sequence of extractions, shown in Figure 1-9 of Attachment 1.0, will be modified to test the uniqueness of an individual extraction.

5.4.3.2 Partitioning of Soil Fractions

<u>Fraction 1. Carbonates.</u> In the soil environment, carbonates are susceptible to changes in pH which will induce the release of adsorbed plutonium. Carbonates will be removed by 0.5 molar (M) sodium acetate-acetic acid buffer solution (NaC₂H₃O₂H₂O), adjusted to pH 5. This buffer treatment removes metals held in carbonates (coprecipitate with carbonates and/or adsorbed by iron and manganese oxides which have precipitated onto the carbonates) (Jenne, 1977). This buffer apparently does not attack the resistant sesquioxide phases to any great extent and leaves the lattice structure of silicate minerals intact (Chao, 1984).

<u>Fraction 2. Organic.</u> In natural conditions, organic carbon is gradually decomposed, which may lead to release of soluble and colloidal plutonium. The organic carbon will be extracted by NaOCl at pH 9.5. Lavkulich and Wiens (1970) removed up to 98 percent of the oxidizable organic carbon from 16 soil samples by three successive extractions with sodium hypochlorite. The sodium hypochlorite treatment is the preferable solution for extracting plutonium from soil organic matter because it does not appear to dissolve sesquioxide phases. It should be noted, however, that sodium hypochlorite will attack sulfides that may be present in the sample.

<u>Fraction 3. Sesquioxides.</u> Sesquioxides are excellent scavengers of trace metals and are extremely unstable under anoxic conditions. There are various techniques to extract iron, manganese, and aluminum oxides in soils. These methods were developed to selectively dissolve the various mineralogical forms and degree of fineness of the sesquioxides present in soils. In the context of the proposed study, the citrate-bicarbonate-dithionite buffer method (Jackson, et al., 1986) is superior to other methods because it dissolves amorphous sesquioxides completely whereas the highly crystalline sesquioxides (e.g., hematite and goethite) will be partially dissolved. The degree of dissolution of the highly crystalline sesquioxides is dependent on the crystallinity and the fineness of grinding of the oxides. Hence, in order to obtain complete dissolution of crystalline sesquioxides, the soil samples will be finely ground and three multiple extractions will be performed.

<u>Fraction 4. Residue.</u> After removal of the above chemical phases from the soil sample, the residue consists of silicates and some other resistant mineral species such as ilmenite and magnetite. The residue will be dissolved by strong digestion with hydrofluoric acid (HF) in conjunction with perchloric acid (HCIO₄).

Experimental Conditions

- (a) Bound to Carbonates. The soils will be extracted for 5 hours with 20 m² of 1M sodium acetate-acidic acid solution adjusted to pH 5.0. Detailed description of this extraction is given by Nelson (1982).
- (b) Bound to Organics. The residue from (a) will be extracted for 5 hours with 20 m² of 1M sodium hypochlorite solution adjusted to pH 9.5. Detailed description of this extraction is given by Hoffman and Fletcher (1981).
- (c) Bound to Sesquioxides. The residue from (b) will be extracted for 6 hours with 100 m² of 0.3M sodium citrate mixed with 1M sodium carbonate solution and appropriate amounts of sodium dithinite and sodium chloride salts. This extract will be repeated three times to assure almost complete dissolution of highly crystalline iron oxides. Detailed description of the extraction is given by Jackson, et al. (1986).

(d) Residual. The residue from (c) will be digested by a 5:1 mixture of hydrofluoric and perchloric

acids. For a 1-gram (dry weight) sample, the soil will be first digested in a platinum crucible

with a solution of concentrated $HCIO_4$ (2m ℓ) and HF (10m ℓ) to near dryness. Subsequently,

a second addition of HClO₄ (1ml) and HF (10ml) will be made, and again the mixture will be

brought to near dryness. Finally, HClO₄ (1ml) will be added and the sample will be evaporated

until the appearance of white fumes. Further details of this extraction is given by Lim and

Jackson (1982).

After each extraction the sample will be centrifuged at 10,000 revolutions per minute (rpm) for 30 minutes.

The supernatant will be removed with a pipet and prepared for plutonium analysis. The residue will be washed

with 10 ml of deionized water to remove residual salt from the previous extraction. The volume of the rinse

water will be kept at a minimum to avoid excessive solubilization of organic matter.

5.4.3.3 Tracer Study

Spikes of plutonium-237 will be added to soil samples (triplicates) before each extract step (Figure 1-9;

Attachment 1.0). The percentage of spike recovery and possible readsorption of the tracer will be carefully

determined. In case of serious postextraction readsorption (> 15 percent) the selective sequential extraction

will not be performed. In case the selective sequential extraction procedure is rejected, samples collected from

pits X1 to X5 will only be analyzed for total plutonium-239, and 240 and americium-241.

5.4.4 Mobile Soil Phase - Physicochemical Association of Plutonium and Americium

The mobility and the environmental fate of actinides in soils are usually studied by extracting the soil matter.

In general, these analyses fail to provide important information regarding the transport mechanisms of

pollutants within the soil column. Hydrological analysis of the frequency, duration and intensity of summer

precipitation events and spring snowmelt events, coupled with direct measurements of solute transport in soils

will provide essential information to assess the form and magnitude of actinide movement in soil.

5.4.4.1 Objectives and Hypotheses

The objectives of the proposed mobile soil phase work are to:

Estimate the importance of vertical flow in the soil environment upslope from seep SW-53

during and after major precipitation events.

Assess the relationships between soil-plutonium in the interstitial waters and plutonium in the

seep SW-53.

The proposed design is based on the following three hypotheses:

Leaching episodes in the soils will transport solute and colloidally-bound actinides down the soil column.

Freely flowing waters in the soil environment will carry different actinide concentrations than soil

solutions collected at higher matrix potentials.

The occasional elevated concentrations of plutonium in seep SW-53 were originated by vertical

leaching of plutonium from the soil environment upslope.

5.4.4.2 Mobile Phase - Proposed Work

Testing these hypotheses will require in situ sampling of soil interstitial waters over time. More specifically, it

will be necessary to develop a fully-automated, remote-controlled soil solution sampling system that is capable

of: (a) collecting freely flowing water [0 to 5 kiloPascals (kPa) matrix potential] mainly via macropores; (b)

collecting soil solutions flowing in micropores at higher matrix potential (5 to 40 kPa); and (c) provide accurate

and timely measurements of incoming precipitation. This apparatus will consist of five major modules:

An automated zero-tension sampler in which freely flowing water, mainly in macropores (formed by frost heave cycles and swelling and shrinking of clays), will be accurately collected for

assessing the subsurface flow during and after major precipitation events.

A fluxmeter which will provide the unsaturated flux as the soil dries out as well as soil solutions

for radiochemistry analyses.

Tipping bucket rain gauge.

Time domain reflectometry (TDR) soil moisture probes which will measure in situ soil water

content.

Telemetry communication which will send the data collected in the field to a base station at

T130B (Figure 1-10; Attachment 1.0).

The vertical water flow data obtained in situ will be used to test the infiltration rates and flow estimates

calculated by the unsaturated flow model, being developed by CSU (mid-1991), for the area east of the 903

Pad. The chemical characterization study will include: (1) total concentrations of plutonium and americium in

soil interstitial waters that move freely (0 to 5 kPa) down the soil column and (2) fractionation of actinides in

colloidal and dissolved [< 0.1 micrometer (µm)] phases in freely flowing waters (0 to 5 kPa) and various matrix

potentials (5 - 10; 10 to 30; and 30 to 50 kPa).

The chemical characterization will be performed using zero-tension samplers and fluxmeters. The zero-tension

sampler will be made of 40-centimeter segments of plexiglass (25-centimeter width) with one end plugged with

a plexiglass stopper containing a collecting tube and the other end sharpened. The sharpened end will be driven into the western pit face with a mallet to a depth of 40-centimeters to ensure minimal structure and textural disturbance to the soil. The water sampled by the zero-tension sampler will be collected by a 2 liter bottle mounted on a load cell. The temperature of the soil interstitial waters and the soil matrix will be measured by a temperature probe. The temperature and amount of water in the collection bottle will be

The transmitted information will be transferred daily to the base station via telemetry. Sending the data via telemetry to the base station (T130B) will provide crucial information regarding the time and frequency of field sampling.

simultaneously transmitted to a data logger.

The soil test pits will be refilled after access tubes are inserted to prevent convergence flow and to minimize further disturbance. The zero-tension soil solution samplers will be installed upslope of seep SW-53 every 10 to 15 centimeters down the soil column to the depth of the caliche horizon or other semi-impermeable layer in the five soil profiles (site X1 through X5; Figure 5-10).

The fluxmeter consists of three components: a Teflon cylinder soil water sampler which is treated with silica to reduce hydrophobicity; three TDR soil moisture probes; and a portable vacuum pump with a buffer container. Each Teflon sampler will be installed with three TDR soil moisture probes around it and connected, via Teflon tubing, to a 2-liter collecting bottle equipped with a special screw cap of polyethylene with a teflon gasket and fittings. The 2-liter collecting bottle will be residing inside a thermo-box which will minimize temperature fluctuations in the field. Two types of Teflon cylinder soil water samplers will be used: a teflon cylinder with an average pore size of 10 μ m for sampling large water volumes during short flow episodes; and a teflon cylinder with an average pore size of 5 μ m for normal operational conditions. Ten Teflon cylinder soil water samplers will be installed at five different depths in each pit (X1 through X5; Figure 5-10) excavated for the zero-tension sampler. The Teflon cylinder soil water samplers will be installed into the face of the soil pit using a stainless-steel rod. The soil moisture probes will be connected via coaxial cable to a Tektronix cable tester, equipped with a communication interface, to a datalogger (Figure 1-12; Attachment 1.0). Once the soil moisture of the soil exceeds a pre-set value the vacuum pump will be activated to produce an equivalent vacuum inside the tension sampler. The equivalent vacuum will be derived from the linear relationships between soil moisture and matrix potential values in the range of 0.1 to 50 kPa.

The soil interstitial waters collected by the zero-tension samplers and the tension samplers will be filtered on the day of sampling using 0.45 and 0.1 μ m Millipore filters. The total colloidal bound plutonium will be determined from the material that was retained on the filters. The dissolved plutonium will be determined from the water that passed through the filter.

The frequency, duration and intensity of summer precipitation will be determined by a tipping bucket rain gauge. This rain gauge is an integral part of the proposed apparatus and will be mounted in the middle of the transect. The rain gauge will simultaneously transfer the data to the data logger which will transmit this information via telemetry to the base station in T130B. The amount and nature of precipitation and soil water flux will be recorded and checked daily. The frequency of field sampling will be determined on the basis of the transmitted data. This data will be used to prepare a precipitation model for hydrologic simulation and analysis.

The amount of water that can be collected by this apparatus in Rocky Flats Plant soils is currently unknown. One to 2 liters of interstitial waters were collected every week during snowmelt and after every major precipitation event in forested and alpine ecosystems using a simplified version of the proposed apparatus (Litaor, 1988). Hence, two rain simulation experiments will be conducted before the beginning of the precipitation season. The first experiment will be used to verify that all the components of the apparatus are interfacing and communicating with each other and the base station. Calibration of the load cells and the TDR soil moisture probes will be performed during the first rain simulation experiment. The magnitude and duration of the second simulated rain will be determined by reviewing precipitation data collected at Rocky Flats Plant in the last 5 years to determine the magnitude and frequency of the storm events. Soil solution collected during the second simulation experiment will be submitted for radionuclides analyses.

5.4.4.3 Rain Simulation

The importance of hydrologic model simulation of rain and snow precipitation in the proposed work can be summarized as follows: (1) rain simulation yields more rapid results, especially in the testing of the extreme conditions (e.g., rainfall in arid and semi-arid conditions); and, (2) rain simulation is more controlled inasmuch as one can take appropriate measurements with selected intensities and durations. The rain simulator described by Ghodrati, et al. (1990) will be used in the proposed work. This rain simulator can employ spatially uniform application of water to small plots (1 to 2 m²). The simulated rainwater will have the same ionic strength as the average rainwater observed at Rocky Flats Plant.

5.5 FIELD AND ANALYTICAL LABORATORY PROGRAMS

Field testing will include headspace tests for organics, gross alpha and beta radiological tests, geologic logging, photography, and hydrologic tests. All of the above are field screening and data logging activities described in the SOPs. The hydrologic testing will be conducted as proposed below. All of these data will be incorporated into the EG&G Rocky Flats data base.

5.5.1. Hydraulic Testing Program

Three multi-well pumping and tracer tests will be performed to evaluate the hydraulic properties of the subsurface materials at the 903 Pad, Mound, and East Trenches Areas. The goals of the program are to:

- Develop parameters for rate of movement calculations (hydraulic conductivity and effective porosity) for both the bedrock and alluvial materials.
- Evaluate the degree of connection between the alluvium and the bedrock (both sandstone and claystone).
- Develop parameters for estimation of production rates from remedial ground-water collection systems.

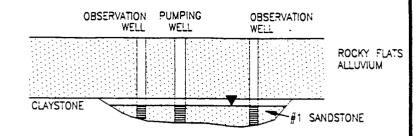
The testing program has been designed based on the hydrogeologic model of the subsurface described in earlier sections of this plan. Three distinct hydrogeologic situations are present in the upper HSU at the 903 Pad. Mound, and East Trenches Areas:

- 1) The Rocky Flats Alluvium is unsaturated and is directly underlain by the of the Arapahoe Number One Sandstone Formation (saturated).
- 2) The Rocky Flats Alluvium is directly underlain by the Number One Sandstone and both are saturated.
- 3) The Rocky Flats Alluvium is saturated and is underlain by claystone of the Arapahoe Formation.

Hydrologic pumping tests have been designed to evaluate hydraulic conductivity, storage properties, and the effective porosity for each of these situations. Schematics of the subsurface conditions and test well layouts are shown on Figure 5-9.

Detailed designs for each of the hydrologic pumping tests are presented below; however, before the tests are actually performed, the production wells will be installed and tested (step-drawdown or other single hole technique) to establish better estimates of the hydraulic properties at the test locations. The hydrologic tests will then be re-evaluated and possibly re-designed (observation well locations, pumping rates and duration of pumping). After re-evaluation of the test designs, the observation wells will be installed and the hydrologic tests will be performed. All water produced during the hydrologic pumping testing of the production wells will be stored in tanker trucks and reinjected into the production well from which the water was produced.

MULTI-WELL PUMPING TEST CONVERGING RADIAL TRACER TEST

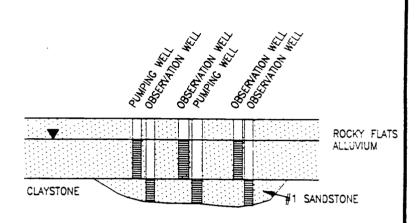


TEST T-2:

SATURATED ALLUVIUM & SATURATED SANDSTONE

PUMPING TEST OF ALLUVIUM WITH OBSERVATION WELLS IN SANDSTONE

PUMPING TEST OF SANDSTONE WITH OBSERVATION WELLS IN ALLUVIUM

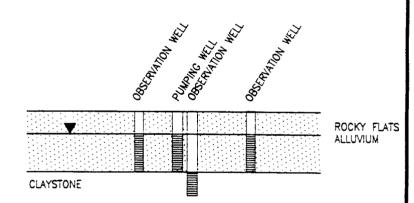


TEST T-3:

SATURATED ALLUVIUM UNDERLAIN BY CLAYSTONE

PUMPING TEST OF ALLUVIUM WITH OBSERVATION WELL IN CLAYSTONE

CONVERGING RADIAL TRACER TEST



U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

HYDRAULIC TEST DIAGRAMS

FIGURE 5-9

August, 1991

5.5.1.1 Case 1. Unsaturated Alluvium over Saturated Sandstone

A multi-well pumping test followed by a converging radial tracer test will be performed at the T-1 location

shown on Plate 1. An array of 1 production well and four observation wells will be completed in the Number

One Sandstone. The observation wells will be located at distances of 5, 10, 20 and 40 feet from the production

well (Figure 5-10).

Initial pump rates will be determined by using Theis (1935) and hydraulic properties developed in the Phase

IRI (hydraulic conductivity of 4x10⁻⁴ centimeter/s, storage coefficient of 0.1 and saturated thickness of 15 feet).

A steady pumping rate of 1 gpm is estimated for wells at the T-1 location. If the test array is located

approximately 40 feet from the edge of the sandstone channel, significant interference from the boundary

(additive drawdown of 0.5 feet) should be observable in the most distant observation well after 5 days of

pumping. All produced water (7,200 gallons) will be stored in tanker trucks and then reinjected into the

production well at the end of the recovery period (see below).

Immediately following the 5 days of steady pumping, a converging radial tracer test will be performed by

injecting rhodamine-WT dye into the observation well located 5 feet from the production well (steady pumping

will continue throughout the tracer test). It is anticipated that the 50 percent concentration (C_{so}) will arrive at

the production well approximately ten hours after introduction of the fluorescent dye. The entire pump test will

require approximately 24 hours to complete. The tracer test results will be analyzed using methods described

by Sauty (1980).

After completion of the tracer test recovery of the system will be monitored for an additional 6 days.

Drawdowns in the observation and production wells will be evaluated using methods described in Bedinger

and Reed (1988), such as Neuman (1972 and 1973).

5.5.1.2 Case 2. Saturated Alluvium over Saturated Sandstone

Two multi-well pumping tests will be performed at the T-2 location shown on Plate 1. An array of one

production well and four observation wells will be completed in the Rocky Flats Alluvium, and a second array

of one production well and four observation wells will be completed in the Number One Sandstone. The

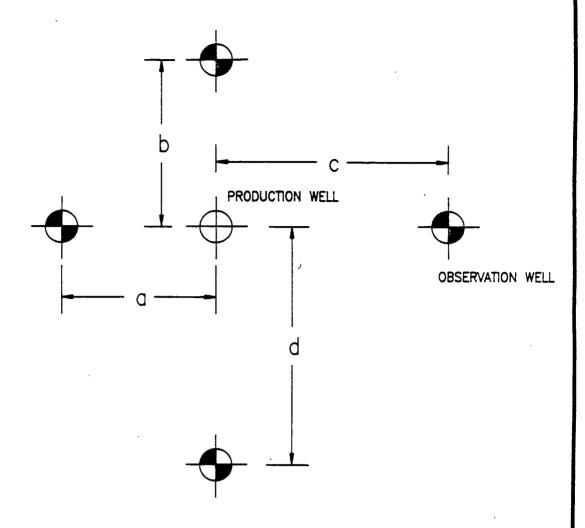
observation wells in the Rocky Flats Alluvium will be located at distances of 5, 10, 30 and 75 feet from the

production well. The observation wells in the Number One Sandstone will be located at distances of 5, 10, 20

and 40 feet from the production well (Figure 5-10).

A 5-day production test of the Rocky Flats Alluvium will be performed with an additional 5 days of recovery.

Water level responses will be measured in wells that monitor in both the alluvium and the sandstone. A second



EXPLANATION OF WELL SPACINGS (FEET)

	a	þ	С	d
Sandstone	5	10	20	40
Alluvium	5	10	30	75

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OPERABLE UNIT NO. 2
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OBSERVATION WELL LAYOUT

FIGURE 5-10

August, 1991

5-day production test of the sandstone will be performed with monitoring of observation wells in both the

alluvium and the sandstone. The test period will be designed based on previous pump test data. A tracer test

will not be performed as part of this test because of expected interference (dilution effects) from the overlying

or underlying units.

The pumping test of the sandstone will be conducted at 1 gpm (see discussion of Case 1 above for expected

production volume and aquifer responses). An estimated steady pumping rate of 3 gpm flow from the alluvium

has been calculated using the Theis Method (1935), and alluvial hydraulic properties developed in the

Phase I RI (hydraulic conductivity of 1x10⁻² cm/s, storage coefficient of 0.1 and saturated thickness of 5 feet).

At the end of the recovery period for the second test, all produced water (22,000 gallons from the alluvium and

7,200 gallons from the sandstone stored in separate tanker trucks) will be reinjected into the production well

from which the water came.

Drawdowns in the observation and production wells will be evaluated using numerical modeling techniques,

such as Lappala, et al. (1987), as well as the more standard methods described in Bedinger and Reed (1988).

However, because the hydrogeologic conditions do not meet the assumptions of the standard leaky-aquifer

analyses, it is anticipated that numerical modeling will be the effective method to evaluate the interconnection

between the alluvium and the sandstone.

5.5.1.3 Case 3. Saturated Alluvium over Claystone

A multi-well pumping test followed by a converging radial tracer test will be performed at the T-3 location

shown on Plate 1. An array of one production well and four observation wells will be completed in alluvium.

The observation wells will be located at distances of 5, 10, 30 and 75 feet from the production well (Figure

5-10). In addition, a single observation well will be installed adjacent to the production well to monitor head

response at a depth of approximately 5 feet into the claystone.

An estimated steady pumping rate of three gpm flow from the alluvium has been calculated using the Theis

Method (1935), and alluvial properties developed in the Phase I RI (hydraulic conductivity of 1x10⁻² cm/s,

storage coefficient of 0.1 and saturated thickness of 5 feet). All produced water (22,000 gallons) will be stored

in tanker trucks and reinjected into the production well at the end of the recovery period. Using a simple finite-

difference evaluation, it is estimated that a water level response will be measurable in the claystone (0.1 feet

of drawdown for a vertical conductivity of 1x10⁻⁶ cm/s) after 5 days of pumping.

Immediately following the 5 days of steady pumping, a converging radial tracer test will be performed by

injecting rhodamine-WT dye into the observation well located 5 feet from the production well. It is anticipated

that the 50 percent concentration will arrive at the production well approximately 1 hour after the introduction

Final Phase II RFI/RI Work Plan (Alluvial) - 903 Pad, Mound, and East Trenches Rocky Flats Plant, Golden, Colorado Technical Memorandum 1 of the fluorescent dye, and that the entire test will require approximately 24 hours to complete. The tracer test will be analyzed using methods described by Sauty (1980).

After completion of the tracer test, recovery of the system will be monitored for an additional 6 days. Drawdowns in the observation and production wells in the alluvium will be evaluated using methods described in Bedinger and Reed (1988). The response of the observation well in the claystone will be evaluated using methods described in Bedinger and Reed (1988), such as Lappala, et al. (1987).

5.5.2 Ground-water Sampling Program

Ground-water samples will be collected on a quarterly basis from all new and existing monitoring wells at the 903 Pad, Mound, and East Trenches Areas upon completion of well development. Samples will be analyzed for the parameters listed in Table 5-3 during the first round of sampling after completion of new wells. This parameter list may be reduced in subsequent quarterly sampling events if certain parameter groups are not detected, or are not significantly above background levels and if approved by EPA and CDH. Ground-water samples will be analyzed in the field for pH, conductivity, temperature, and dissolved oxygen. Sample aliquots designated for metals and radionuclide analyses will be filtered with the exception of tritium. All sample filtration and preservation will be performed in the field.

5.5.3 Borehole Sampling Program

Borehole samples will be collected from boreholes within and adjacent to IHSSs to characterize both plumes and sources. Selected borehole samples will be analyzed for the chemical parameters listed in Table 5-3 following CLP methods or the methods provided in the GRRASP (EG&G, 1990k) plan. These parameters are essentially the same as those analyzed in the Phase I RI except that oil and grease and RCRA characteristics are eliminated. Oil and grease have not proven useful in determining extent of soil contamination, and RCRA hazardous waste characteristics have been within acceptable limits. The TCL list for organics and the TAL list for inorganics are nearly the same as the previously used HSL list for organics and inorganics.

The physical properties of on-site geologic materials will also be characterized to support the evaluation of remedial action alternatives. Bulk samples will be collected from continuous core of alluvial wells to characterize each of the materials found within the 903 Pad, Mound and East Trenches Areas. (Rocky Flats Alluvium, colluvium, valley fill alluvium, and weathered bedrock). Specifically, 10 samples of each geologic material type will be submitted for grain size analyses (sieve and hydrometer analyses), Atterberg limits testing, and recompacted permeability testing to evaluate the variability of these parameters across the site.

TABLE 5-3

PHASE II RFI/RI SEDIMENT, BOREHOLE, SURFACE WATER, AND GROUND-WATER SAMPLING PARAMETERS

SAMPLING PARAMETERS				
TOTAL METALO	METALS			
TOTAL METALS	Target Analyte List -			
Target Analyte List -	Ground Water (Dissolved Metals)			
Sediment and Boreholes	and Surface Water (Total and Dissolved Metals)			
Atuminum	Aluminum			
Antimony	Antimony			
Arsenic	Arsenic			
Barium				
Beryllium	Barium Danilia			
Cadmium	Beryllium			
Calcium	Cadmium			
Chromium	Calcium			
Cobalt	Chromium			
Copper	Cobalt			
Iron	Copper			
Lead	Iron			
Magnes i um	Lead			
Manganese	Magnes i um			
Mercury	Manganese			
Nickel	Mercury			
Potassium	Nickel			
Selenium	Potassium			
Silver	Selenium			
Sodium	Silver			
Sociedii Thallium	Sodium			
·····	Thallium			
Vanadium 	Vanadium			
Zinc				
	Zinc			
OTHER NETALS	OTHER METALS			
***************************************	Ground Water and Surface Water			
Sediment and Boreholes				
Molybdenum	Molybdenum			
Strontium	Strontium			
Cesium	Cesium			
Lithium	Lithium			
Tin	Tin .			
ATUES 1488644166	FIELD PARAMETERS			
OTHER INORGANICS	Ground Water and Surface Water			
Sediment and Boreholes				
рн	pH · · ·			
Sulfide	Specific Conductance			
Nitrate-Nitrite (as N)	Temperature			
Percent Solids	Dissolved Oxygen			
Cyanide				
Moisture Content	1ND1CATORS			
Orthophosphate	Ground Water and Surface Water			
Bromide	Total Dissolved Solids			
Ammonium	Total Organic Carbon			
Silica (as Si and SiO ₂)	Dissolved Organic Carbon			
31 Cica (83 31 and 3102)	pH			
INDICATORS	F''			
Sediment and Boreholes	INDICATORS			
Dissolved Organic Carbon	Surface Water Total Suspended Solids			
Total Organic Carbon	lotal Suspended Sollos			
OTHER PARAMETERS	ANIONS			
Total Petroleum Hydrocarbons*	Ground Water and Surface Water			
Total Petroteum nyurocarbons	Carbonate			
	·· - ··-			
	Bicarbonate Chloride			
	Sulfate			
	Nitrate as N			
	Cyanide			
	fluoride			
	Bromide			
	Silica (as Si and SiO ₂)			
	Ammon i um			
	Orthophosphate			

Sheet 1 of 4

TABLE 5-3 (Continued)

PHASE II RF1/RI SEDIMENT, BOREHOLE, SURFACE WATER, AND GROUND-WATER SAMPLING PARAMETERS

OTHER PARAMETERS

Ground Water

Total Petroleum Hydrocarbons*

DISSOLVED RADIOMUCLIDES**

Ground Water and Surface Water
Gross Alpha
Gross Beta
Uranium -233&234,235, and 238
Americium -241 (surface water only)
Plutonium -239&240 (surface water only)
Tritium
Strontium -89,90

Strontium -89,90 Cesium 137 Radium 226,228*** Tritium

TOTAL RADIOMUCLIDES

Surface Water
Uranium -233&234,235, and 238
Plutonium -239&240
Americium -241
Cesium -137
Strontium -89,90
Radium -226,228**
Tritium

Ground Water

Plutonium -239&240 Americium -241 Tritium

ORGANICS: VOLATILES

TOTAL RADIOMUCLIDES

Sediment and Boreholes

Tritium

Gross Alpha Gross Beta

Americium -241

Plutonium -239&240

Strontium -89,90

Cesium -137 Radium -226, 288

Uranium -233&234,235, and 238

Target Compound List -Sediment and Boreholes Chloromethane Bromomethane Vinyl Chloride Chloroethane Methylene Chloride Acetone Carbon Disulfide 1,1-Dichloroethene 1.1-Dichloroethane total 1,2-Dichloroethene Chloroform 1,2-Dichloroethane 2-Butanone 1,1,1-Trichloroethane Carbon Tetrachloride Vinyl Acetate Bromodichloromethane 1,1,2,2-Tetrachloroethane 1,2-Dichloropropane trans-1,3-Dichloropropene Trichloroethene

Dibromochloromethane

Benzene

Toluene

Bromoform

2-Hexanone

Chlorobenzene

1,1,2-Trichloroethane

4-Methyl-2-pentanone

Tetrach Loroethene

cis-1,3-Dichloropropene

ORGANICS: VOLATILES

Target Compound List -Ground Water and Surface Water Chloromethane Bromomethane Vinyl Chloride Chloroethane Methylene Chloride Acetone Carbon Disulfide 1,1-Dichloroethene 1,1-Dichloroethane total 1,2-Dichloroethene Chloroform 1,2-Dichloroethane 2-Butanone 1,1,1-Trichloroethane Carbon Tetrachloride Vinyl Acetate Bromodichloromethane 1,1,2,2-Tetrachloroethane 1,2-Dichloropropane trans-1,3-Dichloropropene Trichloroethene Dibromochloromethane 1,1,2-Trichloroethane Benzene cis-1,3-Dichloropropene Bromoform 2-Hexanone 4-Methyl-2-pentanone Tetrachloroethene Toluene

Chlorobenzene

Sheet 2 of 4

TABLE 5-3 (Continued)

PHASE II RFI/RI SEDIMENT, BOREHOLE, SURFACE WATER, AND GROUND-WATER SAMPLING PARAMETERS

ORGANICS: VOLATILES (continued)
Target Compound List Sediment and Boreholes
Ethyl Benzene
Styrene
Total Xylenes

ORGANICS: VOLATILES (continued)
Target Compound List Ground Water and Surface Water
Ethyl Benzene
Styrene
Total Xylenes

ORGANICS: SENI-VOLATILES Target Compound List -Sediment and Borehole Phenol bis(2-Chloroethyl)ether 2-Chiorophenoi 1,3-Dichlorobenzene 1,4-Dichlorobenzene Benzyl Alcohol 1,2-Dichlorobenzene 2-Methylphenol bis(2-Chioroisopropyl)ether 4-Methylphenol N-Nitroso-Dipropylamine Hexachloroethane Nitrobenzene Isophorone 2-Nitrophenol 2,4-Dimethylphenol Benzoic Acid bis(2-Chloroethoxy)methane 2,4-Dichlorophenol 1,2,4-Trichlorobenzene Naphthalene 4-Chloroaniline Hexachlorobutadiene 4-Chioro-3-methylphenol(para-chiorometa-cresol) 2-Methylnaphthalene Hexachlorocyclopentadiene 2,4,6-Trichlorophenol 2,4,5-Trichlorophenol 2-Chloronaphthalene 2-Nitroaniline Dimethylphthalate Acenaph thy lene 3-Nitroaniline Acenaph thene 2,4-Dinitrophenol 4-Nitrophenol Dibenzofuran

2.4-Dinitrotoluene 2,6-Dinitrotoluene Diethylphthalate 4-Chlorophenyl Phenyl ether Fluorene 4-Nitroaniline 4,6-Dinitro-2-methylphenol N-nitrosodiphenylamine 4-Bromophenyl Phenyl ether Hexach Lorobenzene Pentachi orophenol Phenanthrene Anthracene Di-n-butylphthalate Fluoranthene Pyrene **Butyl Benzylphthalate** 3,3'-Dichlorobenzidine Benzo(a)anthracene bis(2-ethylhexyl)phthalate

ORGANICS: SEMI-VOLATILES Target Compound List -Ground Water and Surface Water**** Phenol bis(2-Chloroethyl)ether 2-Chlorophenol 1,3-Dichlorobenzene 1,4-Dichlorobenzene Benzyl Alcohol 1,2-Dichlorobenzene 2-Methylphenol bis(2-Chloroisopropyl)ether 4-Methylphenol N-Nitroso-Dipropylamine Hexachloroethane Nitrobenzene Isophorone 2-Nitrophenol 2,4-Dimethylphenol Benzoic Acid bis(2-Chloroethoxy)methane 2,4-Dichlorophenol 1,2,4-Trichlorobenzene Naphthalene 4-Chloroaniline Hexach Lorobutadiene 4-Chloro-3-methylphenol(para-chloro-metacresol) 2-Methylnaphthalene Hexach Lorocyc Lopentadiene 2,4,6-Trichlorophenol 2.4.5-Trichtorophenot 2-Chloronaphthalene 2-Nitroaniline Dimethylphthalate Acenaph thy lene 3-Nitroaniline Acenaphthene 2,4-Dinitrophenol 4-Nitrophenol Dibenzofuran 2,4-Dinitrotoluene 2,6-Dinitrotoluene Diethylphthalate 4-Chlorophenyl Phenyl ether Fluorene 4-Nitroaniline 4,6-Dinitro-2-methylphenol N-nitrosodiphenylamine 4-Bromophenyl Phenyl ether Hexach Lorobenzene Pentachlorophenol Phenanthrene Anthracene Di-n-butylphthalate Fluoranthene Pyrene

Butyl Benzylphthalate

3.31-Dichlorobenzidine

bis(2-ethylhexyl)phthalate

Benzo(a)anthracene

Sheet 3 of 4

TABLE 5-3 (Continued)

PHASE II RFI/RI SEDIMENT, BOREHOLE, SURFACE WATER, AND GROUND-WATER SAMPLING PARAMETERS

ORGANICS: SENI-VOLATILES (continued)
Target Compound List Sediment and Borehole
Chrysene
Di-n-octyl Phthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

ORGANICS: SEMI-VOLATILES (continued)
Target Compound List Ground Water and Surface Water****
Chrysene
Di-n-octyl Phthalate
Benzo(b)fluoranthene
Benzo(a)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

ORGANICS: PESTICIDES/PCBs Target Compound List -Sediment and Boreholes alpha-BHC beta-BHC delta-BHC gamma-BHC (Lindane) Heptachlor Aldrin Heptachlor Epoxide . Endosulfan I Dieldrin 4.41-DDE Endrin Endosulfan II 4.41-DDD Endosulfan Sulfate 4.41-DDT Endrin Ketone Methoxychlor alpha-Chlordane gamma-Chlordane Toxaphene AROCLOR-1016 AROCLOR-1221 AROCLOR-1232

ORGANICS: PESTICIDES/PCBs Target Compound List -Ground Water and Surface Water**** alpha-BHC beta-BHC delta-BHC gamma-BHC (Lindane) Heptachlor Aldrin Heptachlor Epoxide Endosulfan I Dieldrin 4.41-DDE Endrin Endosulfan II 4.41-000 Endosulfan Sulfate 4.41-DDT Endrin Ketone Methoxychlor alpha-Chlordane gamma-Chlordane Toxaphene AROCLOR-1016 AROCLOR-1221 AROCLOR-1232 AROCLOR-1242 AROCLOR-1248 AROCLOR-1254 AROCLOR-1260

SURFICIAL SOIL SAMPLE PARAMETERS

Total Organic Carbon
Organic Carbon Extraction****
Carbonate
Carbonate Extraction****
Residual Extraction*****

AROCLOR-1242

AROCLOR - 1248

AROCLOR - 1254

AROCLOR - 1260

pH Specific Conductance Plutonium-239 & 240 Americium-241

- For samples collected from IHSSs 102 and 105 only (65-91/BH0191, BH0291, 66-91/BH0391, BH0491, 67-91/BH0591, 68-91/BH0691, BH0791, BH0891, BH0991, BH1591, 72-91/BH1691, BH1791, BH1891).
- ** Samples for total radionuclides for groundwater will be collected if sufficient water can be evacuated from the well to fill the appropriate containers.
- *** Decision tree. If Gross Alpha is ≥ 5 pCi/ℓ the sample will be analyzed for Radium-226,228.
- **** Semi-volatiles and Pesticide/PCB samples are collected during the quarterly surface water sampling events.
- ***** See Attachment 1.0, Section 1.5.3.2 for extraction methodologies.
- NOTE: The priority list for ground-water sample parameters for wells which yield insufficient water to obtain the entire analytical suite is provided in the ER Program SOPs.

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5.5.4 Surficial Soils Analyses

Composite surficial soil samples collected from the 40 2.5-acre grids (Figure 5-9) will be analyzed for

plutonium-239, 240 and americium-241. Samples obtained from the 84 sites selected within 10-acre grids will

be analyzed for plutonium and americium. These analyses will be used to determine the spatial distribution

of actinides in the surficial soils at Rocky Flats Plant east of the 903 Pad.

Soil samples from the 26 soil profiles will be analyzed for plutonium and americium to assess their vertical

distribution in the soils. Soil organic carbon, soil pH, calcium carbonate content, and specific conductance will

also be determined on samples from each of the soil profiles. All samples from the 26 profiles will be subjected

to the carbonate and organic carbon extractions described in Section 5.1.3.3. In addition, samples from

profiles X1 through X5 will also be subjected to sesquioxide and residue extractions.

In conjunction with the chemical analyses, soil physical measurements will also be conducted on samples from

selected soil profiles. Specifically, particle size analysis and bulk density will be performed on a sample from

one profile representative of each soil type (Table 2-2 and Figure 2-6).

5.5.5 Surface Water and Sediment Sampling Programs

Surface water and sediment samples are being collected from seeps and bodies of water within South Walnut

and Woman Creek drainages as part of monthly site-wide water quality programs. The sample stations of most

importance to OU No. 2 are shown in Table 5-4. This water quality data set is available for analyses as part

of the OU No. 2 Phase III RFI/RI report and for the two work plans in alluvium and bedrock media.

5.5.5.1 Sample Locations

Nineteen surface water and seep water stations were established south of the 903 Pad and East Trenches

Areas in the Woman Creek drainage during the 1986 and 1987 investigations; 12 stations were also established

north of the Mound and East Trenches Areas in the South Walnut Creek drainage in 1988. These 31 existing

stations are being sampled monthly during the site-wide routine sampling program with the exception of SW-21,

SW-24, and SW-25, which have been eliminated as sampling stations. Four new sampling locations have been

added. Station SW-132 is located approximately 225 feet downstream of SW-61, where flow from the upper

reach of South Walnut Creek is discharged from the outlet of a corrugated metal culvert, and SW-133 is located

at the concrete culvert discharge to the South Walnut Creek drainage just north of SW-60. Monthly samples

are also being collected from Ponds C-1 and C-2. Figure 2-11 presents surface water monitoring locations in

the area, and Table 5-4 lists the two surface water stations.

TABLE 5-4
SURFACE WATER SAMPLING STATIONS

Station Number	Seep	Stream	Pond	<u>Ditch</u>	<u>Other</u>	Area	Note*
SW-21		x				Mound	
SW-22				X		Mound	1
sw-23		X				Mound	2
SW-24		X				S. Walnut Creek	2
sw- 25		X				S. Walnut Creek	1
SW-26		X				Woman Creek	1
SW-27				x		SID	2
SW-28					X Pond	Woman Creek	2
sw-29					X Pipe	Woman Creek	2
sw-30				x		SID	2
sw-50	x					903 Pad	
SW-51	X					903 Pad	2 2 2
sw-52	X					903 Pad	2
sw-53	X					903 Pad	2
SW-54					X	SID	2
SW-55					X	881	2
SW-56	X					Mound (PA)	2 2
sw-57	. X					903 Pad	
sw-58	X					903 Pad	2
sw-59	X					Mound	2
SW-60		X				Mound	2
SW-61		· X				Mound	2
SW-62	X					Woman Creek	2
SW-63	X					903 Pad	2
SW-64	X					903 Pad	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
SW-65	X					East Trenches	2
sw-70				X	•	SID	. 2
sw-77	×					903 Pad	
SW-101	X					Mound (PA)	2.
sw-102	X					Mound (PA)	2 2 2
sw-103	X					Mound	2
sw-132					X New	Mound	2
sw-133					X New	Mound	2
SW-C1		X				Woman Creek	2
SM-C2	•	X				Woman Creek	2

^{• 1 -} Station not sampled as EMAD site-side routine sampling program.

^{• 2 -} Station sampled monthly as part of EMAD site-side routine sampling program.

SID - South Interceptor Ditch

Sediment samples were taken in October 1989 at stations along South Walnut Creek as well as Woman Creek and the SID. The resulting data should suffice as confirmatory information regarding the concentrations of volatile organics, metals, other inorganics, and radionuclides in the sediments. For the Phase II RFI/RI, physical characteristics of the sediments (background and "downgradient") and the spatial distribution of the metal concentrations will be examined to assess the adequacy of the background sediment geochemical characterization, and thus whether metals are contaminants in the sediments at the 903 Pad, Mound, and East Trenches Areas.

5.5.5.2 Chemical Analyses of Surface Water and Sediment Samples

Surface water and sediment sampling is being conducted as part of the site-wide routine sampling program. Surface water samples are being analyzed in the field for pH, conductivity, temperature, and dissolved oxygen. Laboratory analyses of surface water and sediment samples consists of the parameters listed in Table 5-3. All samples requiring filtration are filtered in the field, and all samples are preserved in the field. Surface water sampling and stream flow measurements follow the procedures described in the Rocky Flats ER Program SOP.

5.6 DATA MANAGEMENT

Field and laboratory data collected during the Phase II RFI/RI will be incorporated into the RFEDS. The RFEDS is used to track, store, and retrieve project data. Data will be input to the RFEDS via diskettes subsequent to data validation as outlined in the ER Program QAPjP (EG&G, 1990j). Hardcopy reports will then be generated from the system for data interpretation and evaluation.

6.1 INTRODUCTION

The objective of this EEWP is to provide a framework for addressing and quantifying the ecological effects to the biotic environment (plants, animals, and microorganisms) from exposure to contaminants resulting from IHSSs within the 903 Pad, Mound, and East Trenches Areas, (OU No. 2) of the Rocky Fiats Plant. An ecosystem approach will be used as the basis for this environmental evaluation to ensure that ecological effects endpoints (e.g., structural diversity, biomass, phenology, nutrient cycling, trophic structure) are addressed as well as populations and individuals that are more traditionally evaluated in a risk assessment approach (EPA, 1989c). The ecosystem approach is comprehensive in that it initially addresses all ecosystem components, then progressively focuses on those aspects of the system potentially affected by contamination. The result of this process will be an evaluation of the nature and extent of contamination in biota, its relationship to abiotic sources, and the type and extent of adverse effects at the ecosystem, community, and population levels.

This plan is prepared in conformance with the requirements of current applicable legislation, including CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), and follows the guidance for such studies as provided in the NCP and EPA documents for the conduct of RCRA RFI/RI activities. Specifically, the EPA guidance provided in <u>Risk Assessment Guidance for Superfund, Vol. II, Environmental Evaluation Manual</u> (EPA, 1989d) is followed. Although a formal Natural Resource Damage Assessment (NRDA) process has not been initiated at Rocky Flats as of this time, this work plan was also designed to be consistent with the NRDA process to the maximum extent possible.

Determination of the effects on biota will be performed in conjunction with the human health risk assessment for OU No. 2. Where appropriate, criteria necessary for performing the environmental evaluation will be developed in conjunction with human health risk assessments and environmental evaluations for all Rocky Flats Plant operable units. Information from the environmental evaluation will assist in determining the form, feasibility, and extent of remediation necessary for 903 Pad, Mound, and East Trenches Areas in accordance with CERCLA.

During preparation of this work plan, several documents were reviewed as part of an assessment of available information. These included the Final Environmental Impact Statement (EIS), Rocky Flats Plant (DOE, 1980) Wetlands Assessment (EG&G, 1990m); Draft Environmental Evaluation Work Plan for OU No. 2 (in RFI/RI Work Plan, EG&G, 1991d); and the Final Environmental Assessment for OU No. 1 (DOE, 1990b). Literature reviews will continue throughout the environmental evaluation. Review of the Phase II RFI/RI Work Plan for OU No. 2



(EG&G, 1991d) and the Environmental Evaluation Work Plans for OU No. 5 (EG&G, 1991e) and OU No. 1 (EG&G, 1990n) formed the basis for the establishment of the initial sampling locations presented in the OU No. 2 FSP (Subsection 6.3).

6.1.1 Approach

This plan presents a comprehensive approach to conducting the EE at 903 Pad, Mound, and East Trenches Areas. This comprehensive approach is designed to ensure that all procedures to be performed are appropriate, necessary and sufficient to adequately characterize the nature and extent of environmental effects to biota under the "no action" scenario. The approach presented in this plan is adapted from the toxicity-based approach to the assessment of ecosystem effects (EPA, 1989a and 1989c). The approach is based on standard risk assessment concepts whereby uncertainties concerning potential ecosystem effects are explicitly recognized and, where possible, quantified. The planned approach is also based, to the greatest extent possible, on providing objective estimates of ecological damage and establishing a firm, causal relationship between contamination and ecological effects. To establish this relationship, the work plan focuses on the obtainment of three types of information:

- Chemical analyses of appropriate media to establish the presence, Chemical concentrations, and variabilities of specific toxic compounds. This effort will be conducted under the RFI/RI abiotic sampling program.
- Ecological Ecological surveys to characterize the condition of existing communities and establish whether any adverse effects have occurred.
- Toxicological Toxicological and ecotoxicological testing to establish the link between adverse ecological effects and known contamination.

Without these three types of data, other potential causes of the observed effects on ecosystems unrelated to the presence of contamination, such as habitat alterations and natural variability, cannot be eliminated.

The ecological assessment scheme adopted for this project blends standard environmental and risk assessment methods with ecological and toxicological modelling to produce an integrated procedure for selecting contaminants of concern and indicator species, and for conducting an investigation of ecosystem effects resulting from contamination. As is recommended by EPA, this environmental evaluation is not intended to be or to develop into a research-oriented project. The plan presented herein is designed to provide a focused investigation of potential contaminant effects on biota.

Each task of the EE will be coordinated with RFI/RI activities at nearby operable units in order to avoid unnecessary duplication of effort and resources. EE planning is currently underway at two operable units in



close proximity to OU No. 2: OU No. 5 (Woman Creek Drainage) and OU No. 1 (881 Hillside). A coordinated approach with these operable units is necessary in order to account for contaminant migration into OU No. 2.

The EE process has been divided into 10 tasks. These tasks and their interrelationships are shown on Figure 6-1. The following is a brief description of each of these tasks. More detailed descriptions of each task are presented in Subsection 6.2.

Task 1: Preliminary Planning

Task 1 will focus on planning and coordination of the OU No. 2 EE with nearby OU No. 5 and OU No. 1 activities. Task 1 will include a determination of the scope of work and a definition of the study area. The DQO process will be initiated in Task 1 according to EPA guidance (EPA, 1987a or 1990), and procedures for monitoring and controlling data quality will be specified to the extent possible. Task 1 activities will include development of criteria for selection of contaminants of concern, key receptor species, and reference areas.

Task 2: Data Collection/Evaluation and Conceptual Model Development

Task 2 will include a review, evaluation, and summary of available chemical and ecological data and identification of data gaps. Based on these data, contaminants of concern will be identified based on their documented effects on key receptor species and/or other ecological endpoints. As part of the conceptual biota model development, a food web model will be constructed and preliminary exposure pathways will be identified. Results of these activities will be used to refine the ecological (Task 3) and ecotoxicological (Task 9) field investigation sampling designs.

Task 3: Ecological Field Investigation

Task 3 will include the preliminary field surveys, and an ecological field inventory to characterize OU No. 2 biota and their trophic relationships, and to note locations of obvious zones of chemical contamination. Brief field surveys will be conducted in the spring, summer, fall, and winter to obtain information on the occurrence, distribution, variability, and general abundance of key plant and animal species. Field inventories will be conducted in late spring and summer to obtain quantitative data on community composition in terrestrial and aquatic habitats. Samples collected as part of the activity will be saved for tissue analyses where contaminants of concern have been identified and sampling protocol are in place. Task 3 will also include aquatic toxicity tests using *Ceriodaphnia spp* and fathead minnows. As part of these activities, all collected field data will be reduced, evaluated, compared with, and integrated into the existing database to update knowledge of site conditions.

Task 4: Toxicity Assessment

Task 4 will entail compilation of toxicity literature and the toxicological assessment of potential adverse effects

from contaminants of concern on key receptor species. This task will be performed in conjunction with the

following Task 5.

Task 5: Exposure Assessment and Pathways Model

Task 5 will entail development of a site-specific pathways model based on the ecological field surveys. This

exposure-receptor pathways model will be used to evaluate the transport of contaminants at OU No. 2 to

biological receptors. The pathways model is based on a conceptual pathways approach (Fordham and

Reagan, 1991) and will provide an initial determination of the movement and distribution of contaminants, likely

interactions among ecosystem components, and expected ecological effects. It is anticipated that this

approach will be coordinated with the efforts of investigators working in other operable units to avoid

duplication of effort, to collect comparable data, and to provide a consistent assessment of contaminant effects.

Task 6: Preliminary Contamination Characterization

Task 6 will provide a characterization of the threat or risk of OU No. 2 contaminants to receptor populations

and habitats. Determinations will be made as to the magnitude of the effects of contamination on OU No. 2

biota. The actual or potential effects of contamination on ecological endpoints (e.g., species diversity, food

web structure, productivity) will also be addressed. Depending on DQOs and the quality of data collected, the

contamination characterization will be expressed qualitatively, quantitatively, or a combination of the two. Task

6 may include the preliminary derivation of remediation criteria. Development of these criteria will entail

consideration of federal and Colorado laws and regulations pertaining to preservation and protection of natural resources that are ARARs. Information from ARARs, toxicological assessments, and the pathways model will

be used to develop criteria that address biological resource protection.

Task 7: Uncertainty Analysis

Task 7 includes the identification of assumptions and the evaluation of uncertainty in the environmental risk

assessment analysis. Task 7 will include the identification of data needs to calibrate/validate the pathways

model developed in Task 5.

Task 8: Planning

Task 8 will entail the development of additional DQOs with respect to the conduct of Task 9, Ecotoxicological

Field Investigation. DQOs to be achieved by such sampling will be defined according to EPA guidance (EPA,

1987a or 1990). Scoping and design of Task 9 field studies will be based initially on the outcome of Tasks 1

through 3. Field sampling will only be performed where acceptance criteria for demonstrating injury to a

biological resource will be satisfied in accordance with regulations under the Natural Resource Damage

Assessment Rule [40 CFR Subtitle A Section 11.62 (f)] and the accompanying Type B Technical Information

Document (DOI, 1987).

Task 9: Ecotoxicological Field Investigation

Task 9 will include tissue analysis studies and any additional ecotoxicological field investigations. Samples

collected in Task 3 field studies will be used wherever possible (e.g., when contaminants of concern have been

identified and sampling protocols are in place); new samples will be collected if necessary. The need for

measuring additional population endpoints through reproductive success, enzyme inhibition, microbial

respiration, or other ecotoxicological studies will be evaluated based on the Task 3 preliminary ecological risk

assessment. Selection of the target analytes, species, and tissues will be based on the determination of which contaminants are likely to be present in sufficient concentrations, quantities, and locations as to be detected

in biota. Selection of these specific criteria will be developed in consultation with EPA and the State. All

necessary federal and state permits will be obtained prior to any destructive sampling or collecting.

Task 10: Environmental Evaluation Report

Task 10 will provide a final characterization of contamination in biota at OU No. 2. Results from the Task 9

ecotoxicological field investigations will be used to evaluate ecosystem effects. Information on site

environmental characteristics and contaminants, characterization of effects, remediation criteria, conclusions,

uncertainty analysis, and limitations of the assessment will be summarized into the Environmental Evaluation

Report.

Each of the preceding tasks is described in further detail in Subsection 6.2. A suggested outline for the

Environmental Evaluation Report is presented in Subsection 6.2.11. The field sampling plan presented in

Subsection 6.3 addresses both the Task 3 ecological investigation and the Task 9 ecotoxicological field

investigations. A tentative outline for the environmental evaluation report is presented in Subsection 6.2.11.

6.1.2 OU No. 2 Contamination

A number of chemicals are suspected to be present in OU No. 2 soils and surface water at levels above background, as described in Section 2.0 of the Phase II OU No. 2 RFI/RI Work Plan (EG&G, 1991d). To determine above-background chemical levels, a comparison was made between the site-specific data and background data as presented in the Draft Background Geochemical Characterization Report (Rockwell International, 1989h). A background tolerance interval for each analyte of concern was calculated (the maximum concentration detected was used in those cases where no tolerance level could be calculated). A summary of contaminants that were detected above background at any time during sampling, based on the information presented in Section 2.0, is shown in Table 6-1. Most of the contaminants are likely to impact biota if present at sufficient concentrations. The following subsections present a discussion of which of these chemicals are likely to be of paramount concern at OU No. 2, given their toxic nature. Actual selection of contaminants of concern to biota will take place in Task 2 after a more detailed analysis of potential adverse effects and review of available toxicological literature. Further comparisons of site data to the more recent Geochemical Characterization Report (EG&G, 1990g) to determine above background levels will also be made as part of the RFI/RI investigation.

6.1.2.1 Metals

Terrestrial Ecosystems

Heavy metals are the most commonly evaluated environmental contaminants in biomonitoring studies of terrestrial ecosystems. Studies on heavy metals are of several types: (1) reports of metal concentrations in animals from only one location, (2) correlations of tissue concentrations with environmental concentrations, (3) monitoring a site through time, (4) concentrations in animals collected along a gradient of pollution, and (5) comparisons of concentrations in animals from reference and contaminated sites or sites where contamination is suspected. These studies generally provide information on background concentrations of contaminants and correlations of tissue concentrations with environmental concentrations. Data from the Talmage and Walton (1990) study is available for most heavy metals for a variety of mammal species and lower trophic levels. Data from Talmage and Walton (1990) and other available studies on heavy metals effects on biota will be reviewed as part of the Task 2 effort and compared to OU No. 2 data as appropriate.

Several of the heavy metals detected at OU No. 2 are phytotoxic and are known to bioaccumulate and biomagnify in terrestrial and aquatic ecosystems. Bioaccumulation, the process by which chemicals are taken up by organisms directly or through consumption of food containing the chemicals, is documented for

TABLE 6-1

CHEMICALS DETECTED AT OU NO. 2 AT LEVELS ABOVE BACKGROUND

903 PAD

Surface Water:

Organics: methylene chloride, acetone, toluene, chloroform, carbon tetrachloride,

trichloroethene, 1,1,1-trichloroethene, 1,1-dichloroethene, carbon disulfide, tetrachloroethene, 1,2-dichloroethene, ethylbenzene, 1,2dichloroethene (trans), phenol, 2-methylphenol, n-nitrosodiphenylamine,

bis (2-ethylhexyl) phthalate

Metals: zinc, strontium, barium, beryllium, cadmium, chromium, arsenic, iron,

lead, lithium, magnesium, manganese, copper, selenium, silver, aluminum, mercury, tin, vanadium, antimony, cobalt, molybdenum, nickel

Inorganics: nitrate+ nitrite-nitrogen, chloride, sulfate, HCO3-, CO3, cyanide (total)

Radionuclides: uranium-233 and -234, plutonium-241, strontium-89 and -90, americium-

241, cesium-137, tritium, uranium-238, uranium-235, plutonium-239,

radium-226, radium-228

Sediments:

Organics: methylene chloride, acetone, chloromethane, chloroform, trichloroethene

Metals: mercury, molybdenum, aluminum, antimony, arsenic, barium, beryllium,

> calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, nickel, potassium, selenium, silver, sodium, strontium, tin,

vanadium, zinc, cadmium

Inorganics: no data available

Radionuclides: uranium-233, and -234, uranium-235, uranium-238, strontium-89 and -90,

plutonium-239, americium-241, cesium-137, tritium

MOUND

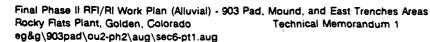
Surface Water:

Organics: toluene. carbon tetrachloride. trichloroethene. acetone.

dichloroethene, methylene chloride, chloroform, 1,1,1-trichloroethene,

1,2-dichloroethene (total), chlorobenzene

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TABLE 6-1 (Continued)

CHEMICALS DETECTED AT OU NO. 2 AT LEVELS ABOVE BACKGROUND

Mound, Surface Water, continued

Metals:

selenium, zinc, chromium, barium, iron, lithium, magnesium, manganese, aluminum, antimony, beryllium, cadmiom, chromium, cobalt, copper,

lead, mercury, molybdenum, nickel, silver, strontium, vanadium

Inorganics:

nitrate+ nitrite-nitrogen, chloride, sulfate, HCO3-, cyanide

Radionuclides:

uranium-233 and -234, uranium-235, uranium-238, plutonium-239,

strontium-89 and -90, americium-241, cesium-137, tritium, radium-226,

radium-228

Sediments:

Organics:

chloroform, acetone, methylene chloride, carbon tetrachloride,

trichloroethene, 2-butanone

Metals:

beryllium, silver, tin, aluminum, lead, cadmium, chromium, copper, iron,

lithium, magnesium, manganese, mercury, strontium, thallium, vanadium,

zinc, arsenic, barium, cobalt, molybdenum, nickel, potassium

Inorganics:

no data available

Radionuclides:

plutonium-239, uranium-233 and -234, radium-226, americium-241,

cesium-137, tritium

Source: Volume II (Appendices), Phase II RFI/RI Work Plan for OU No. 2 (EG&G, 1991a)

EAST TRENCHES AREA

Surface Water:

Organics:

methylene chloride, acetone, carbon tetrachloride, 1,1,1-trichloroethene

Metals:

barium, chromium, iron, lithium, magnesium, manganese, mercury, molybdenum, strontium, antimony, aluminum, beryllium, cobalt, copper,

lead, nickel, selenium, vanadium, arsenic, cadmium, cesium, tin

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TABLE 6-1 (Continued)

CHEMICALS DETECTED AT OU NO. 2 AT LEVELS ABOVE BACKGROUND

East Trenches Areas - Surface Water, continued

nitrate+ nitrite-nitrogen, chloride, sulfate, HCO3-, sulfide, cyanide Inorganics:

Radionuclides: plutonium-239, americium-241, cesium-137, tritium, radium-226, uranium-

233 and -234, uranium-235, uranium-238, strontium-89 and -90, radium-

228

Sediments:

Organics: No data available

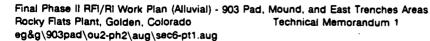
Metals: No data available

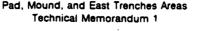
Inorganics: No data available

Radionuclides: No data available

Source: Volume II, Phase II RFI/RI Work Plan for OU No. 2 (EG&G, 1991a).

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arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, and selenium. Biomagnification, or the process by which tissue concentrations of chemicals increase as the chemical passes up through two or more trophic levels, is documented from soil to plants for beryllium, cadmium, chromium, copper, lead, mercury, and selenium. In herbivores, biomagnification occurs for antimony, arsenic, cadmium, chromium, copper, lead, mercury and selenium. In terrestrial carnivores, mercury and cadmium are known to biomagnify. Any, if not all, of these metals are likely to become contaminants of concern in the OU No. 2 EE, depending on historical usage, concentrations detected in soils, and uptake by biological receptors at OU No. 2.

While numerous studies have been conducted with respect to metals effects on biota, there are no readily available criteria for providing an initial rapid assessment of contaminants most likely to be of concern in terrestrial ecosystems. Health-based "environmental action criteria" are available in the RFI Guidance Document (EPA, 1989f) for carcinogens and noncarcinogens in the soils ingestion pathway for humans. These criteria were compared to the maximum contaminant levels (MCLs) for metals in soils and sediments at OU No. 2 to provide an initial assessment of the likely contaminants of concern (Table 6-2). A safety factor of 100 was applied to these criteria, based on the assumption that biota are 100 times more sensitive than humans. It should be noted that only a few of these criteria used are suitable for comparison purposes, as most of the criteria are for metals complexes, whereas concentrations reported for OU No. 2 are for total metals.

Based on this initial comparison of maximum levels detected for metals to the environmental action criteria, beryllium and cyanide are metals whose potential toxic effects should be closely examined with respect to onsite contaminant levels and potential adverse effects on biota. Contaminants such as mercury, cadmium, and lead, for which no environmental criteria are available, will require in-depth evaluations given their considerable potential to biomagnify. It should also be noted that the maximum concentrations reported for alluvium soil in Table 6-2 are from composited samples. Maximum concentrations in uncomposited surficial soils, which are of the greatest concern from an environmental risk perspective, may be considerably higher.

Aquatic Ecosystems

EPA has established ambient water quality criteria (AWQC) to be protective of the environment (EPA, 1986a). Specifically, these criteria represent the maximum allowable water concentrations consistent with the protection of aquatic life. One rationale for establishing criteria protective of aquatic life is that aquatic organisms and plants are important in food chains to higher life forms. In addition, their direct dependence on the aquatic environment results in constant contact with the water and the organisms are therefore likely to assimilate any contaminants. One EPA objective in establishing AWQC was to determine chemical concentrations that would not be directly harmful to aquatic organisms and plants, and would not present a hazard to higher life forms due to any biomagnification of individual chemical substances.

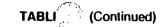
COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR TOTAL METALS TO ENVIRONMENTAL ACTION CRITERIA 903 PAD

				Soil
Parameter	Soil & Sediment Environmental Action Criteria¹ (mg/kg)	Sediment Concentration ^(a) (mg/kg) (Sample #)	Rocky Flats Alluvium Concentration ^(b) (mg/kg) (Sample #) [Depth - Increment (ft.)]	Colluvium Concentration ^(b) (mg/kg) (Sample #) [Depth - Increment (ft.)]
TOTAL METALS				
Aluminum	30²	24,800 (SD030)	14,500 (BH2287) 0.00-9.30	18,900 (BH2787) 0.00-4.80
Antimony	30	24.5 (SD025)	24 (BH2987) 0.00-10.00	
Arsenic		5.5 (SD031)	13.6 (BH2287) 10.60-18.40	17.8 (BH2687) 0.30-2.50
Barium	4,000	300 (SD030)	212 (BH2387) 0.00-7.50	1,899.0 (BH2587) 0.00-9.00
Beryllium	.143	15.5 (SD028)	1.0 (BH3087) 20.00-20.80	1.30 (BH2587) 0.00-9.00
Cadmium		2.3 (SD029)	4.0 (BH3087) 20.00-20.80	5.4 (BH2787) 0.00-4.80
Chromium	III - 80,000 VI - 400	26.8 (SD030)	22.0 (BH2387) 0.00-7.50	21.10 (BH2587) 0.00-9.00
Cobalt	·	8.2 (SD029)	16.2 (BH3087) 11.50-17.15	15 (BH2587) 9.50-10.40



COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR TOTAL METALS TO ENVIRONMENTAL ACTION CRITERIA 903 PAD

			Soil			
Parameter	Soil & Sediment Environmental Action Criteria ¹ (mg/kg)	Sediment Concentration ^(a) (mg/kg) (Sample #)	Rocky Flats Alluvium Concentration ^(b) (mg/kg) (Sample #) [Depth - Increment (ft.)]	Colluvium Concentration ^(b) (mg/kg) (Sample #) [Depth - Increment (ft.)]		
Copper	400 ³	40.4 (SD029)	19 (BH2387) 0.00-7.50	19.8 (BH2687) .030-2.50		
Cyanide	2,000		***			
Iron		28,900 (SD030)	18,200 (BH2387) 0.00-7.50	18,500 (BH2587) 0.00-9.00		
Lead		66.4 (SD030)	13.9 BH3087 11.50-17.15	22.8 (BH2687) 0.30-2.50		
Lithium		27.8 (SD030)		12.71 (BH2687) 0.30-2.50		
Magnesium		5,970 (SD030)	4,010 (BH2387) 0.00-7.50	4368 (BH2587) 0.00-9.00		
Manganese		1,390 (SD030)	1080 (BH2387) 0.00-7.50	356.0 (BH2787) 0.00-4.80		
Mercury		0.56 (SD030)	114.0 (BH2987) 0.00-10.00	0.12 (BH2587) 14.50-15.70		
Molybdenum		12.6 (SD030)				



COMPARISON OF MAXIMUM SOIL AND SEDIMENT **VALUES FOR TOTAL METALS TO ENVIRONMENTAL ACTION CRITERIA** 903 PAD

				Soil			
Parameter __	Soil & Sediment Environmental Action Criteria ¹ (mg/kg)	Sediment Concentration ^(a) (mg/kg) (Sample #)	Rocky Flats Alluvium Concentration ^(h) (mg/kg) (Sample #) [Depth - Increment (ft.)]	Colluvium Concentration ^{b)} (mg/kg) (Sample #) {Depth - Increment (ft.)}			
Nickel	2,000	24.6 (SD034)	2.0 (BH2387) 0.00-7.50	36.10 (BH2587) 9.50-10.40			
Selenium		21.3 (SD030)		·			
Silver	200	49.1 (SD030)					
Strontium		179 (SD030)	74.0 (BH2287) 0.00-9.30	100 (BH2687) 2.15-2.95			
Thallium	20-40 ⁵	•••		•••			
Tin		1,080 (SD030)					
Vanadium	2,000 ⁶	58.4 (SD030)	41.0 (BH2387) 0.00-7.50	50.5 (BH2687) 0.30-2.50			
Zinc	20-4,000 ⁷	140.0 (SD029)	57.8 (BH3087) 11.50-17.15	54.0 (BH2587) 0.00-9.00			



TABLE 6-2 (Continued)

COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR TOTAL METALS TO ENVIRONMENTAL ACTION CRITERIA MOUND

Parameter		•		Soil			
	Soil & Sediment Environmental Action Criteria ⁽¹⁾ (mg/kg)	Sediment Concentration ^(a) (Sample #)(mg/kg)	Rocky Flats Alluvium Concentration ^(b) (mg/kg) (Sample #) [Depth - Increment (ft.)]	Colluvium Concentration ^{to} (mg/kg) (Sample #) [Depth - Increment (ft.)]			
TOTAL METALS	•						
Aluminum	30²	15,100 (SD011)	70,600 (BH3487) 8.00-14.70				
Antimony	30		••	•••			
Arsenic		4.5 (SD011)	15.0 (BH3387) 7.80-14.70				
Barium	4,000	95.3 (SD011)	140.0 (BH3687) 0.00-5.00				
Beryllium	.143	2.5 (SD011)	1.3 (BH3487) 17.00-18.00				
Cadmium		1.4 (SD011)	3.7 (BH3387) 0.00-4.00				
Chromium	III - 80,000 VI - 400	12.7 (SD011)	18.00 (BH3687) 17.70-20.40				
Cobalt		12 (SD011)					
Copper	400³	13.2 (SD011)	25.0 (BH3487) 17.00-19.00				
Cyanide	2,000						
lron		11,000 (SD011)	31,400 (BH3487) 17.00-18.00				

TABLE -2 (Continued)

COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR TOTAL METALS TO ENVIRONMENTAL ACTION CRITERIA MOUND

				Soil			
Parameter	Soil & Sediment Environmental Action Criteria ⁽¹⁾ (mg/kg)	Sediment Concentration ^(a) (Sample #)(mg/kg)	Rocky Flats Alluvium Concentration ^(b) (mg/kg) (Sample #) [Depth - Increment (ft.)]	Colluvium Concentration ^(b) (mg/kg) (Sample #) [Depth - Increment (ft.)]			
Lead		15.4 (SD011)	14.0 BH3687 5.00-15.00				
Lithium		7.2 (SD011)	10.6 (BH3787) 0.00-5.00	·			
Magnesium		2,130 (SD011)	5,260 (BH3387) 0.00-4.00				
Manganese		152 (SD011)	390 (BH3687) 17.70-20.40	 			
Mercury		0.72 (SD011)	0.34 (BH3287) 8.00-15.00	•••			
Molybdenum		2.2 (SD011)					
Nickel	2,000	34.0 (SD011)	21.0 (BH3587) 14.10-15.40				
Selenium			1.5 (BH3887) 9.50-10.85				
Silver	2,000	670 (SD011)					
Strontium		62.4 (SD011)	1845 (BH3787) 0.00-5.00				



COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR TOTAL METALS TO ENVIRONMENTAL ACTION CRITERIA MOUND

			Soil			
Parameter	Soil & Sediment Environmental Action Criteria ⁽¹⁾ (mg/kg)	Sediment Concentration ^(a) (Sample #)(mg/kg)	Rocky Flats Alluvium Concentration ^(b) (mg/kg) (Sample #) [Depth - Increment (ft.)]	Colluvium Concentration ^(b) (mg/kg) (Sample #) [Depth - Increment (ft.)]		
Thallium	20-405	4.1 (SD011)				
Tin		4.0 (SD011)				
Vanadium	2,000 ⁶	35.2 (SD011)	1086 (BH3487) 17.00-18.00			
Zinc	20-4,000 ⁷	140.0 (SD011)	46 (BH3287) 0.00-8.00	·		

TABLE -2 (Continued)

COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR TOTAL METALS TO ENVIRONMENTAL ACTION CRITERIA EAST TRENCHES

			S	oil
Parameter	Soil & Sediment Environmental Action Criteria ⁽¹⁾ (mg/kg)	Sediment Concentration ^(a) (Sample #)(mg/kg)	Rocky Flats Alluvium Concentration ^(h) (mg/kg) (Sample #) (Depth - Increment)	Colluvium Concentration ^(b) (mg/kg) (Sample #) (Depth - Increment)
TOTAL METALS				
Aluminum	304		25,300 (BH5187) 0.00-9.00	
Antimony .	30	***	••	•••
Arsenic			37.0 (BH3987) 0.00-2.00	
Barium	4,000	***	154.0 (BH5487) 2.00-4.00	
Beryllium	.143	, 	1.3 (BH5587) 14.50-23.50	
Cadmium			6.2 (BH3987) 2.00-3.40	
Chromium	III - 80,000 VI - 400		58.0 (BH4387) 14.50-15.80	
Cobalt			12.0 (BH3987) 0.00-2.00	
Copper	400 ³		17.3 (BH5487) 14.20-22.80	
Cyanide	2,000			



COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR TOTAL METALS TO ENVIRONMENTAL ACTION CRITERIA EAST TRENCHES

Parameter				Soil			
	Soil & Sediment Environmental Action Criteria ⁽¹⁾ (mg/kg)	Sediment Concentration ^(a) (Sample #)(mg/kg)	Rocky Flats Alluvium Concentration ^(b) (mg/kg) (Sample #) (Depth - Increment)	Colluvium Concentration ^(b) (mg/kg) (Sample #) (Depth - Increment)			
Iron		·	24,500 (BH4782) 8.00-9.00				
Lead			45.6 BH5187 0.00-9.00				
Lithium	•••						
Magnesium			4950 (BH5487) 14.20-22.80				
Manganese			587 (BH4287) 17.00-18.80				
Mercury			0.34 (BH5487) 8.00-9.65				
Molybdenum			•••				
Nickel	2,000		25.5 (BH4987) 6.00-7:30				
Selenium		· 					
Silver	200	•••					
Strontium			196 (BH5487) 2.00-4.00				
Thallium	20-40 ⁵		***				

TABLE 6-2 (Continued)

COMPARISON OF MAXIMUM SOIL AND SEDIMENT **VALUES FOR TOTAL METALS TO ENVIRONMENTAL ACTION CRITERIA EAST TRENCHES**

			Soil			
Parameter	Soil & Sediment Environmental Action Criteria ⁽¹⁾ (mg/kg)	Sediment Concentration ^(a) (Sample #)(mg/kg)	Rocky Flats Alluvium Concentration ^(b) (mg/kg) (Sample #) (Depth - Increment)	Colluvium Concentration th (mg/kg) (Sample #) (Depth - Increment)		
Tin				•••		
Vanadium	2,000 ⁶		40.2 (BH5487) 14.20-22.80			
Zinc	20-4,0007		55 (BH4187) 14.50-17.00			

Notes:

Risk criteria are the lowest concentrations reported for Health-Based Criteria for Systematic Toxicants and Carcinogens. (Tables 8-6 and 8-7 in EPA, 1989f). Criteria reported in Tables 8-6 and 8-7 (EPA, 1989d) are reduced by 100 to provide a safety factor to biota.

- Criteria for aluminum phosphide.
- 3 Criteria for copper cyanide.
- Criteria for potassium compounds 5
 - Criteria range for thallium compounds.
- Criteria for vanadium pentoxide.
- Criteria range for zinc compounds.
- (a) Values reported in Appendix E of the Final Phase II RFI/RI Work Plan for OU No. 2 (EG&G, 1991a); values reported as either 1) analyzed, but not detected or, 2) rejected, were not considered.
- (b) Values reported in Appendix A of the Final Phase II RFI/RI Work Plan for OU No. 2 (EG&G, 1991a); values reported as either 1) analyzed, but not detected or, 2) rejected, were not considered.

of the maximum levels of metals detected in surface water at OU No. 2, 13 are of immediate interest in the evaluation of aquatic ecosystems given their presence at levels above federal surface water quality standards (Table 6-3). These are aluminum, barium, beryllium, chromium, cadmium, copper, iron, lead, manganese, mercury, selenium, silver, and zinc. Of these metals, chromium, copper, lead, mercury, selenium, and zinc are likely to be contaminants of concern because of their potential to biomagnify. Cyanide, which doesn't necessarily biomagnify, is likely to be a contaminant of immediate concern given its detection at an elevated level and its ability to have direct toxic effects on aquatic organisms. Brief summaries of information from the AWQC document (EPA, 1986a) and other available toxicological literature on these metals of likely concern are presented in the following text. Similar toxicity profiles will be evaluated against site-specific concentrations data in the selection of contaminants of concern and key receptor species. The occurrence of these metals at elevated levels does not necessarily imply that they are available for assimilation in all organisms or that they transfer to successive trophic levels. The potential for adverse effects to occur is dependent upon a number of physicochemical factors including: (1) physiological and ecological characteristics of the organism; (2) forms of dissolved trace metals; (3) forms of trace metals in ingested solids; and (4) chemical and physical characteristics of water (Jenne and Luoma, 1977). Each of these factors will be considered in the evaluation of potential adverse environmental effects at OU No. 2.

<u>Aluminum</u>

No aquatic life criteria have been set, although EPA has promulgated a secondary MCL of 0.050 mg/ ℓ . EPA has suggested ambient concentration limits for the protection of human health, .073 mg/ ℓ for aluminum and aluminum compounds, and .0138 mg/ ℓ for aluminum oxide. The 28-day LC50 (the chemical concentration in water to which test organisms are exposed that is estimated to be lethal to 50 percent of the test organisms) value for aluminum chloride using rainbow trout (*Oncorhynchus mykiss*) is reported at 560 μ g/ ℓ and the 48-hour LC50 value for sodium aluminum silicate using water flea (*Daphnia magna*) is reported to range from 1,000 mg/ ℓ to 1,800 mg/ ℓ .

Barium

In general, the physical and chemical properties of barium are such that it is relatively non-toxic under usual marine and fresh water conditions, and therefore a criterion for aquatic life has not been promulgated. Although many barium salts are soluble in water and are reported to be poisonous, barium ions are thought to be rapidly precipitated or removed via adsorption and sedimentation. In most natural waters, there is sufficient sulfate or carbonate to precipitate the barium present as an insoluble, non-toxic compound. Experimental data indicate that soluble barium concentration in fresh and marine water would have to exceed 50 mg/ ℓ before toxicity to aquatic life would be expected. Criteria have been set for the protection of human health: 1.0 mg/ ℓ for water and fish ingestion, and the same (1.0 mg/ ℓ) as a drinking water MCL.

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR METALS TO FEDERAL AND STATE WATER QUALITY STANDARDS ($\mu g/I$) 903 PAD

			FE	DERAL STAN	DARDS		STATE STA	ANDARDS	
				or Protection uatic Life [®]			arameters for lic Life ^(d)	Stream Se Standa	
Parameter	Maximum Value Reported ^(a)	Location	Acute	Chronic	MCL ^(c)	Acute	Chronic	Acute	Chronic
Aluminum	50,000	SW-54			.050 ⁽³⁾	950	150		}
Antimony	416	SW-54	9000 ⁽²⁾	1600 ⁽²⁾					
Arsenic ⁽⁴⁾	14.6	SW-54	360-III 850-V	190-III 48-V	.050			50	
Barium	1,920	SW-26			0.100				
Beryllium	460.	SW-26	130 ⁽²⁾	5.3 ⁽²⁾					
Cadmium	46.0	SW-26	3.9 ⁽⁵⁾	1.1	.010	TVS	TVS	TVS	TVS
Cesium									·
Chromium ⁽⁴⁾	196	SW-26	1700-III 16-VI	210-III 11.0-VI	.050 .100 ⁽¹⁾	TVS-III 16-VI	TVS-III 11.0-VI		
Cobalt	440	sw-26				li li			
Copper	244	SW-26	18 ⁽⁵⁾	12 ⁽⁵⁾		TVS	TVS	TVS	TVS
Cyanide			22	5.2 ·		5	5	5	5
Iron	50,400	SW-54		1000	.300 ⁽³⁾		1000		300
Lead	109	SW-54	82 ⁽⁵⁾	3.2 ⁽⁵⁾	.50	TVS	TVS	TVS	TVS
Lithium	3,200	SW-55							<u>.</u>
Magnesium	56,700	SW-64	·						
Manganese	2,020	SW-54			.50 ⁽³⁾				50
Mercury	1.0	SW-26	2.4	0.012	.002			.01	
Molybdenum	333	SW-54			•				
Nickel	65.40	SW-50	1400 ⁽⁵⁾	160 ⁽⁵⁾		TVS	TVS	TVS	TVS



COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR METALS TO FEDERAL AND STATE WATER QUALITY STANDARDS $(\mu g/I)$ 903 PAD

					FEDERAL STANDARDS			STATE STANDARDS			
			AWQC for Protection of Aquatic Life ^(b)						arameters for lc Life ^(d)	Stream S Stand	
Parameter	Maximum Value Reported ^(a)	Location	Acute	Chronic	MCL ^(c)	Acute	Chronic	Acute	Chronic		
Selenium	12.60	SW-77	260	36	.010	135	17	10			
Silver	0.0504	SW-26	4.1 ⁽⁵⁾	0.120 ⁽⁵⁾ 50	.050	TVS	TVS	TVS	TVS		
Strontium	1,360	SW064					ŀ				
Tin	1,530	SW-54					ļ				
Vanadium	148	SW-54									
Zinc	7,210	SW-66	120 ⁽⁵⁾	110 ⁽⁵⁾	5000 ⁽³⁾	TVS	TVS	TVS	· TVS		

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR METALS TO FEDERAL AND STATE WATER QUALITY STANDARDS (\(\varphi g/\)\) MOUND

			FEI	FEDERAL STANDARDS	RDS		STATE STANDARDS	ANDARDS	
			AWQC for Aqual	AWQC for Protection of Aquatic Life ^(b)		Biological Pa	Biological Parameters for Aquatic Life ⁽⁴⁾	Stream Stand	Stream Segment Standard ⁽⁴⁾
Paramotor	Maximum Value	notation	Acuto	Chronic	3	Action	Chronic	91.04	oje od d
r al alliere	Heported	LOCATION	ainov		MCL	Acute		Acule	Critonic
Aluminum	24,120	SW-101			.050 ⁽³⁾	950	150		
Antimony	102	SW-59	9000 _[3]	1600 ^{ra}					
Arsenic ⁽⁴⁾	i		360-III 850-V	190-III 48-V	.050			20	
Barium	2,200	SW-101			0.100				
Beryllium	57.20	SW-101	130 ^{P3}	5.38					
Cadmium	14.20	SW-101	3.9 ⁽⁵⁾	-	.010	TVS	TVS	TVS	TVS
Cesium	İ								
Chromium ⁽⁴⁾	212	SW-101	1700-III 16-VI	210-III 11.0-VI	.050	TVS-III 16-VI	TVS-III 11.0-VI		
Cobalt	132	SW-101							
Copper	293	SW-101	18 ⁽⁵⁾	12 ⁽³⁾		TVS	TVS	TVS	TVS
Cyanide	ł	1	22	5.2		လ	S	2	S
Iron	204,000	SW-101		1000	.300(3)		1000		300
Lead	215	SW-101	82 ⁽⁵⁾	3.2 ⁽³⁾	.050	TVS	.SA1	, TVS	TVS
Lithium	2,560	SW-59							
Magnesium	36,700	SW-101							
Manganese	3,680	SW-101			.050 ⁽³⁾				20
Mercury	2.0	SW-101	2.4	0.012	.002			10.	
Molybdenum	174	SW-101							
Nickel	246	SW-101	1400(5)	160 ⁽⁵⁾		TVS	TVS	TVS	TVS
Selenium	16.0	SW-59	260	36	.010	135	17	10	
Silver	11.70	SW-101	4.1 ⁽⁵⁾	0.120(5)	.050	TVS	TVS	TVS	ZVS
Strontium	1,360	SW-59							



COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR METALS TO FEDERAL AND STATE WATER QUALITY STANDARDS $(\mu g/I)$ MOUND

	Maximum Value Reported ^(a)	Location	FE	DERAL STANDA	RDS		STATE ST	ANDARDS	
				Protection of tic Life ^(b)			arameters for ic Life ^(d)	Stream Segment Standard ^(e)	
Parameter			Acute	Chronic	MCL ^(c)	Acute	Chronic	Acute	Chronic
Tin									
Vanadium	555	SW-101							
Zinc	2,660	SW-59	120 ⁽⁵⁾	110 ⁽⁵⁾	5000 ⁽³⁾	TVS	TVS	TVS	TVS

Sheet 5 of 6

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR METALS TO FEDERAL AND STATE WATER QUALITY STANDARDS (\(\varphi g/\elline{t}\)

			FE	FEDERAL STANDARDS	ARDS		STATE STANDARDS	NDARDS	
			AWGC for	AWQC for Protection of Aquatic Life ^(b)		Biological P. Aquati	Biological Parameters for Aquatic Life ⁽⁴⁾	Stream Star	Stream Segment Standard ^(e)
Parameter	Maximum Value Reported ⁽⁴⁾	Location	Acute	Chronic	MCL ⁶⁾	Acute	Chronic	Acute	Chronic
Aluminum	169,000	SW-103			.050(1)	950	150		
Antimony	0.06	SW-103	₂₀ 000€	1600 ⁶³					_
Arsenic ⁽⁴⁾	44.80	SW-103	360-III 850-V	190-III 48-V	.050			05	
Barium	4,230	SW-103			.100		_		
Beryllium	25.10	SW-65	130 ⁽²⁾	5.34					
Cadmium	24.10	SW-103	3.9 ⁽⁵⁾	1:	.010	TVS	TVS	TVS	TVS
Cesium	1,110	SW-103							
Chromium ⁽⁴⁾	85.50	SW-65	1700-III 16-VI	210-III 11.0-VI	.100(1)	TVS-III 16-VI	TVS-III 11.0-VI		
Cobalt	224	SW-103							_
Copper	70.20	SW-65	18(5)	12 ⁽⁵⁾		TVS	TVS	TVS	TVS
Cyanide	i		22	5.2		ß	S	2	2
Iron	70,900	SW-65		1000	$0.300^{(3)}$		1000		300
Lead	65.60	SW-103	82 ⁽⁵⁾	3.2 ⁽⁵⁾	.050	TVS	TVS	NS.	TVS
Lithium	116	SW-103							
Magnesium	56,800	SW-103		_					
Manganese	10,700	SW-103			.050 ⁽³⁾				20
Mercury	6.0	SW-103	2.4	0.012	.002			9.	
Molybdenum	114	SW-103							
Nickel	273	SW-103	1400(5)	160 ⁽⁵⁾		TVS	TVS	ZVS	TVS
Selenium	2.0	SW-65	260	36	010.	135	17	01	
Silver			4.1 ⁽⁵⁾	0.120(8)	.050	TVS	TVS	TVS	TVS
Strontium	2,270	SW-103							





COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR METALS TO FEDERAL AND STATE WATER QUALITY STANDARDS $(\mu g/t)$ EAST TRENCHES

	Maximum Value Reported ⁽⁴⁾	Location	FE	DERAL STAND	DARDS		STATE STAN	IDARDS	
				or Protection uatic Life ^(b)	MCL ^(c)	Biological Parameters for Aquatic Life ^(a)		Stream Segment Standard ^(e)	
Parameter			Acute	Chronic		Acute	Chronic	Acute	Chronic
Tin	312	SW-65						1 - 1	
Vanadium	178	SW-65	ļ				,		
Zinc	772	SW-103	120 ⁽⁵⁾	110 ⁽⁵⁾	5000 ⁽³⁾	TVS	TVS	TVS	TVS

Explanation of Table:

- Maximum Value Reported is for Total Recoverable Metals as reported in Appendix C of Final RFI/RI Work Plan for OU No. 2 (EG&G, 1991d); values reported either 1) analyzed but not detected, or 2) rejected, were not considered.
- (b) EPA Quality Criteria for Water, 1986.
- EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990).
- (d) CDH/WQCC, Colorado Water Quality Standards 3.1.0 (5 CCR 1002-8) 1/15/1974, amended 9/30/1989 (Environmental Reporter 726: 1001-1020: 6/90).
- ^(e) CDH/WQCC, Classifications and Numeric Standards for S. Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin 3.8.0 (5 CCR 1002-8) 4/6/1981, amended 2/15/90.

AWQC = Ambient Water Quality Criteria

MCL = Maximum Contaminant Level

SDWA = Safe Drinking Water Act
TVS = Table Value Standard

WQCC = Water Quality Control Commission

- SDWA MCL from EPA National Primary and Secondary Drinking Water Regulations 40 CFR Parts 141, 142, and 143; Final Rule Effective, July 30, 1992.
- Insufficient data to develop criteria; Lowest Observed Effects Level (LOEL).
- (3) Secondary MCL.
- Standards given for arsenic(III) and arsenic(V); Chromium (III) and Chromium(VI).
- (5) Hardness dependent criteria.

Beryllium .

Based on available data, beryllium has been shown to be toxic to freshwater aquatic life at low concentrations.

Acute toxicity occurs at concentrations as low as 0.130 mg/l, and chronic toxicity at 0.0053 mg/l. Hardness

has been found to have a substantial effect on acute toxicity. Species that are more sensitive to beryllium than

those tested would experience toxic effects at lower concentrations.

Chromium(VI)

The toxicity of chromium is largely due to its oxidizing action in its hexavalent state (as chromic oxide,

chromate, or dichromate) and its easy permeation of biologic membranes (NRC, 1974). Acute toxicity values

for chromium(VI) are available for freshwater animal species in 27 genera; these values range from 23.07 µg/ℓ

for a cladoceran to 1,870,000 μ g/ ℓ for a stonefly. These species include a wide variety of animals that perform

a wide spectrum of ecological functions. Daphnids are especially sensitive. The few data that are available

indicate that the acute toxicity of chromium(VI) decreases as hardness and pH increase.

The chronic value for both rainbow trout and brook trout is 264.6 μ g/ ℓ ; while the chronic value for fathead

minnow is 1,987 μ g/ ℓ . Chronic tests using chinook salmon show a reduction in growth at low concentrations

(16 μ g/ ℓ). Chronic values in soft water for daphnids range from <2.5 to 40 μ g/ ℓ and acute-chronic ratios

range from 1.130 to >9.680 $\mu g/\ell$. Green algae are quite sensitive to chromium(VI). The bioconcentration

factor (BCF) for rainbow trout is less than 3.

Copper

The toxicity of copper to aquatic organisms is due primarily to the cupric (Cu2+) ion and possibly to some of

the hydroxy complexes. Concentrations of copper ranging from 1 to 8,000 $\mu q/\ell$ inhibit growth of various

aquatic plant species. Sensitivities for aquatic invertebrates and fish are similar to those for plants. Acute

toxicity data are available for species in 41 genera of freshwater animals. At a hardness of 50 mg/l, the

genera range in sensitivity from 16.74 μ g/ ℓ for *Ptychocheilus* to 10,240 μ g/ ℓ for *Acroneuria*. Acute toxicity

generally decreases as water hardness increases. Additional data for several species indicate that toxicity also

decreases with increases in alkalinity and total organic carbon. Chronic values are available for 15 freshwater

fish species and range from 3.873 $\mu g/\ell$ for brook trout to 60.36 $\mu g/\ell$ for northern pike. Fish and invertebrate

species seem to be equally sensitive to the chronic toxicity of copper.

Protection of animal species appears to offer adequate protection of plants. Copper does not appear to

bioconcentrate very much in the edible portion of freshwater aquatic species. Many animals have some ability

to cope with excess copper through excretion (Rand and Petrocelli, 1985). In animals where copper is not

excreted, copper will accumulate in tissues, especially in the liver.

<u>Cvanide</u>

The acute toxicity of free cyanide (the sum of cyanide present as HCN and CN', expressed as CN) to various

freshwater species involved in diverse community functions ranged from 44.73 μ g/ ℓ to 2,490 μ g/ ℓ . All of the

species with acute sensitivities above 4 μ g/ ℓ were invertebrates. A long-term survival and a partial and life-

cycle test with fish gave chronic values of 13.57, 7.849, and 16.39 μ g/ ℓ , respectively. Chronic values for two

freshwater invertebrate species were 18.33 and 34.6 μ g/l. Freshwater plants were affected at cyanide

concentrations ranging from 30 μ g/ ℓ to 26,000 μ g/ ℓ .

<u>Lead</u>

The acute toxicity of lead to several species of freshwater animals has been shown to decrease as the

hardness of water increases. At a hardness of 50 mg/ ℓ , the acute sensitivities range from 142.5 μ g/ ℓ for an

amphipod to 235,900 μ g/ ℓ for a midge. Data on the chronic effects of lead on freshwater animals are available

for two fish and two invertebrate species. The lowest and highest available chronic values (12.26 and

128.1 μ g/ ℓ) are both for a cladoceran, but in soft and hard water respectively. Freshwater algae are affected

by concentrations of lead above 500 $\mu g/\ell$, based on data for four species. BCFs are available for four

invertebrate and two fish species and range from 42 to 1,700.

Several enzymes are sensitive to lead at very low concentrations. Lead strongly inhibits several ATPases,

lipoamide dehydrogenase, and aminolevulinic acid dehydratase, which is involved in the synthesis of heme

(Rand and Petrocelli, 1985). In vertebrate animals, lead poisoning is characterized by neurological defects,

kidney dysfunction, and anemia.

<u>Manganese</u>

Generally, manganese does not constitute a toxicity problem in fresh water. Ions of manganese are rarely

found at concentrations greater than 1 mg/ ℓ , and tolerance values range from 1.5 to 1,000 mg/ ℓ .

Permanganates have been known to kill fish in 8 to 18 hours at concentrations of 2.2 to 4.1 mg/l, but these

compounds are not persistent because they are rapidly reduced and rendered non-toxic in the presence of

organic matter. In marine waters, manganese is a major problem due to bioconcentration in edible portions

of mollusks; bioaccumulation factors up to 12,000 have been reported.

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No criteria for protection of aquatic life have been set; criteria for the protection of human health have been established at 50 μ g/ ℓ for water and fish ingestion and 100 μ g/ ℓ for fish consumption only. A secondary MCL standard for drinking water at 50 μ g/ ℓ has also been established.

Mercury

Mercury is toxic to all forms of biota in aquatic ecosystems, although many factors (e.g., alkalinity, pH, and temperature) influence toxicity. The toxic action of mercury in plants and animals appears to involve cell membranes and their permeability. In mammals, early subacute poisoning generally has a neurological manifestation (Rand and Petrocelli, 1985). Data are available on the acute toxicity of mercury(II) to 28 genera of freshwater animals. Acute values for invertebrate species range from 2.2 μ g/ ℓ for Daphnia pulex to 2,000 μ g/ ℓ for three insects. Acute values for fish range from 30 μ g/ ℓ for the guppy to 1,000 μ g/ ℓ for Mozambique tilapia. Few data are available for various organomercury compounds and mercurous nitrate, which are 4 to 31 times more acutely toxic than mercury(II).

Available chronic data indicate that methylmercury is the most chronically toxic of the tested mercury compounds. Tests on methylmercury with *Daphnia magna* and brook trout show chronic values less than 0.07 μ g/ ℓ . For mercury(II), the chronic value for *Daphnia magna* is about 1.1 μ g/ ℓ and the acute-chronic ratio (median lethal concentration sufficient to produce short term effects/concentration producing effects after long term exposure) is 4.5. In both a life-cycle test and an early life-stage test on mercuric chloride with the fathead minnow, the chronic value was less than 0.26 μ g/ ℓ and the acute-chronic ratio was over 600.

Freshwater plants show a wide range of sensitivities to mercury, but the most sensitive plants appear to be less sensitive than the most sensitive freshwater animals to both mercury(II) and methylmercury. A BCF of 4,994 is available for mercury(II); BCFs for methylmercury range from 4,000 to 85,000.

Selenium

Although selenium can be quite toxic, it has been shown to be an essential trace nutrient for many aquatic and terrestrial species and has also been shown to ameliorate the effects of a variety of pollutants (e.g., arsenic, cadmium, copper, and mercury). Invertebrates have been shown to be both the most sensitive and the most resistant freshwater species to selenium(IV). Acute values for *Daphnia spp. range* from 6 μ g/ ℓ to 3,870 μ g/ ℓ for selenium(IV). Acute values in fish for selenium(IV) range from 620 μ g/ ℓ for fathead minnow to 35,000 μ g/ ℓ for carp. The final chronic value for selenium(IV) of 27 μ g/ ℓ is based on sensitivities of rainbow trout. Based on data for three species, selenium(IV) was shown to be 5 to 32 times more toxic than selenium(VI). Although selenium(IV) appears to be more acutely and chronically toxic than selenium(VI) to most aquatic animals, this



does not seem to be true for aquatic plants. Growth of several species of green algae were affected by concentrations ranging from 10 to 300 μ g/ ℓ . BCFs that have been obtained for selenium (IV) with freshwater species range from 2 for the muscle of rainbow trout to 452 for the bluegill. Highest concentrations of selenium(IV) have been found in fish viscera, due to the uptake of selenium adhering to food.

Silver

Silver is one of the most toxic metals to freshwater aquatic life. The forms of silver that are commonly found in bodies of water and are not measured by the total recoverable procedure, such as the silver in minerals, clays, and sand, probably are forms that are less toxic to aquatic life and probably will not be readily converted to the more toxic forms under natural conditions. The forms of silver that are commonly found in bodies of water and are measured by the total recoverable procedure, such as the free ion and the hydroxide, carbonate, and sulfate salts, are forms that are more toxic to aquatic life or can be converted to the more toxic forms under natural conditions. The toxicity of silver is dependent on the hardness of the water, with acute toxicity apparently decreasing as hardness increases. At hardnesses of 50, 100, and 200 mg/ ℓ as CaCO³, the concentration of total recoverable silver should not exceed 1.2, 4.1, and 13 μ g/ ℓ , respectively, at any time, if aquatic life is to be protected.

Acute toxicity data for silver are available for 10 species of freshwater animals from 9 different taxonomic families that perform a wide variety of community functions. For the four invertebrate species tested, the acute values for silver range from 0.25 μ g/ ℓ for Daphnia magna to 4,500 μ g/ ℓ for the scud, Gammarus pseudolimnaeus. Most of the acute values for freshwater fish are for the rainbow trout and fathead minnow. The acute values in flow-through tests range from 3.9 μ g/ ℓ for the fathead minnow in soft water to 280 μ g/ ℓ for rainbow trout in hard water. The range of acute values for the fish species tested is much less than the range of acute values for invertebrate species.

Available data indicate that chronic toxicity to freshwater aquatic life may occur at concentrations as low as $0.12 \ \mu g/\ell$. Chronic values from three chronic toxicity studies with rainbow trout ranged from 0.04 to $0.27 \ \mu g/\ell$. Bioconcentration factors for three insect species were calculated to range from 15 to 240. The bioconcentration factor for bluegills exposed during a 28-day test was less than 1. The adverse effect concentrations of silver on freshwater plants range from 30 to 7,500 $\mu g/\ell$. The adverse effects of silver on freshwater plants are unlikely at concentrations which will not adversely affect freshwater animals.

Zinc

The levels of dietary zinc at which toxic effects are evident depend markedly on the concentration ratio of zinc to copper (Rand and Petrocelli, 1985). Zinc is also a metabolic antagonist of cadmium, so that high zinc intakes in animals afford some protection against cadmium exposure. Acute toxicity values are available for 43 species of freshwater animals. Data indicate that acute toxicity generally decreases as hardness increases. When adjusted to a hardness of 50 mg/ ℓ , sensitivities range from 50.70 μ g/ ℓ for Ceriodaphnia reticulata to 88,960 μ g/ ℓ for a damselfly. Additional data indicate that toxicity increases as temperature increases. Chronic toxicity data are available for nine freshwater species. Chronic values for two invertebrates range from 46.73 μ g/ ℓ for Daphnia magna to >5,243 μ g/ ℓ for the caddisfly, Clistoronia magnificia. Chronic values for seven fish species range from 36.41 μ g/ ℓ for flagfish, Jordanella floridae, to 854.7 μ g/ ℓ for the brook trout, Salvelinus fontinalis. The sensitivity range of freshwater plants is greater than that for animals. Growth of the alga, Selenastrum capriocornutum, is inhibited by 30 μ g/ ℓ ; however, 4-day EC50s (median effective concentration sufficient to produce some response in 50 percent of test organisms) for several other species of green algae exceed 200,000 μ g/ ℓ . Zinc bioaccumulates in freshwater animal tissues at 51 to 1,130 times the water concentration.

6.1.2.2 Radionuclides

Basic ecological research on radionuclides in the environment has a 40-year history resulting in sophisticated models for identification and prediction of the movement and concentration of specific radionuclides. The same is true for effects on humans resulting from exposure to both external and internal sources of radiation. Most of the scientific literature concerning radioecology has resulted from interaction between DOE-operated facilities and nearby universities.

The following discussion is a brief summary of the radionuclide literature reviewed. In general, transuranics tend to bind in the soils and sediments and have limited availability to biota. Bioaccumulation or concentration factors routinely are low between trophic levels. Data from Little et al. (1980) from the Rocky Flats Plant site indicate that radionuclide inventories (and thus radiation doses) in vertebrate populations are well below levels know to elicit effects.

Maximum values reported for radionuclides in soils, sediments, and surface water at OU No. 2 are shown in Tables 6-4 and 6-5. Environmental action criteria similar to those used in Section 6.1.2.1 for metals are not available for radionuclides. Maximum values for radionuclides in surface water as reported for OU No. 2 (EG&G, 1991d) were compared to federal and state surface water quality standards to identify any contaminant levels of immediate concern (Table 6-5). Values for total gross alpha, dissolved and total gross beta, total

TABLE 6-4

SUMMARY OF MAXIMUM TOTAL RADIONUCLIDE VALUES IN SOILS AND SEDIMENTS
903 PAD

Call (Allerium)	Maximum Concentration	Commis #	Depth Interval
Soil (Alluvium)	(pCi/g)	Sample #	(ft.)
Gross Alpha	480 ± 50	BH3087	0.00 - 9.00
Gross Beta	27 ± 6	BH2287	0.00 - 9.30
Uranium-233, -234	0.70 ± 0.17	BH3087	0.00 - 9.00
Uranium-238	0.65 ± 0.16	BH3087	0.00 - 9.00
Strontium-89, -90	1.1 ± 0.5	BH2387	0.00 - 7.50
Plutonium 239,-240	180 ± 10	BH3087	0.00 - 9.00
Americium 241	22 ± 6	BH3087	0.00 - 9.00
Cesium 137	1.6 ± 0.8	BH2987	0.00 - 10.00
Tritium	$0.14 \pm 0.20 \text{ (pCi/ml)}$	BH2287	0.00 - 9.30
Total Uranium	1.350	BH3087	0.00 - 9.00
SEDIMENT			
Gross Alpha	77 ± 20	SD030	
Gross Beta	46 ± 6	SD030	
Uranium-233, -234	2.1 ± 0.4	SD025	
Uranium 235	0.1 ± 0.1	SD029, SD030	
Uranium-238	2.7 ± 0.4	SD025	
Strontium 89, 90	0.5 ± 0.8	SD030	
Plutonium-239, -240	3.3 ± 0.1	SD025	
Americium-241	0.01 ± 0.02	SD030	
Cesium-137	0.5 ± 0.1	SD030	
Tritium	0.20 ± 0.16 (pCi/ml)	SD029	
Radium 226	1.3 ± 0.1	SD030	
Radium 228	1.9 ± 0.3	SD030	
Total Uranium	4.8		

Values reported in Phase II RFI/RI Work Plan for OU No. 2, Appendixes A and E (EG&G, 1991d); rejected values were not considered.

TABLE 6-4 (continued)

SUMMARY OF MAXIMUM TOTAL RADIONUCLIDE. VALUES IN SOILS AND SEDIMENTS MOUND

Soil (Alluvium)	Maximum Concentration (pCi/g)	Sample #	Depth Interva (ft.)
Gross Alpha	33 ± 14	BH3487	8.00 - 14.70
Gross Beta	37 ± 7	BH3487	8.00 - 14.70
Uranium-233, -234	1.6 ± 0.4	BH3687	17.70 - 20.40
Uranium 238	3.1 ± 0.3	BH3787	0.00 - 5.00
Strontium-89, -90	0.6 ± 0.4	BH3187	0.00 - 11.70
Plutonium-239	2.6 ± 0.3	BH3787	0.00 - 5.00
Americium-241	0.48 ± 0.24	BH3787	0.00 - 5.00
Cesium-137	2.1 ± 1.2	BH3687	5.00 - 15.00
Tritium	0.69 ± 0.22 (pCi/ml)	BH3287	5.00 - 15.00
Total Uranium	4.400	BH3787	0.00 - 5.00
SEDIMENT			
Gross Alpha	19 ± 9	SD011	
Gross Beta	24 ± 6	SD011	
Uranium-233, -234	1.2 ± 0.2	SD011	
Uranium-235	0.2 ± 0.1	SD011	
Uranium-238	1.2 ± 0.2	SD011	
Strontium-89, -90	0.1 ± 0.4	SD011	
Plutonium-239, -240	0.10 ± 0.03	SD011	
Americium 241	0.02 ± 0.02	SD011	
Cesium 137	0.0 ± 0.1	SD011	
Tritium	0.18 ± 0.16 (pCi/ml)	SD011	
Radium 226	0.7 ± 0.1	SD011	
Radium 228	1.4 ± 0.2	SD011	
Total Uranium	2.600		

Values reported in Phase II RFI/RI Work Plan for OU No. 2, Appendixes A and E (EG&G, 1991d); rejected values were not considered.





TABLE 6-4 (continued)

SUMMARY OF MAXIMUM TOTAL RADIONUCLIDE VALUES IN SOILS AND SEDIMENTS EAST TRENCHES

Soil (Alluvium)	Maximum Concentration (pCi/g)	Sample #	Depth Interval (ft.)
Gross Alpha	54 ± 7	BH5687	0.00 - 5.00
Gross Beta	32 ± 7	BH4387	4.00 - 5.30
Uranium-233, -234	3.4 ± 0.3	BH5687	17.00 - 18.90
Uranium-238	3.9 ± 0.3	BH5687	
Strontium-89, -90	1.1 ± 0.5	BH3987	12.00 - 14.00
Plutonium-239, -240	6.0 ± 0.2	BH5387	0.00 - 18.00
Americium-241	0.53 ± 0.20	BH5387	0.00 - 18.80
Cesium-137	1.1 ± 0.1	BH4987	6.00 - 7.30
Tritium	$0.37 \pm 0.20 \text{ (pCi/ml)}$	BH4287	22.00 - 24.50
Total Uranium	7.3	BH5687	17.00 - 18.90
SEDIMENT	No Data		

Values reported in Phase II RFI/RI Work Plan for OU No. 2, Appendixes A and E (EG&G, 1991d); rejected values were not considered.



COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR RADIONUCLIDES TO FEDERAL AND STATE SURFACE WATER QUALITY STANDARDS 903 PAD

			FEDERAL STANDARDS		STREAM ON STANDARDS ⁽⁴⁾
Analyte	Dissolved Concentration (pCi/I)	Total Concentration (pCi/l)	SDWA Maximum Contaminant Level	Basin Table D Radionuclide Standards	Table 2- Radionuclide Standard for Woman Creek
Gross Alpha	8.48 ± 4.74 (SW053)	350 ± 40 (SW055)	15 pCi/l		7 pCi/l
Gross Beta	9.02 ± 4.79 (SW028)	100 ± 13 (SW062)	4 mrem/yr		5 pCi/l
Strontium-89 ± 90	0.0 ± 0.5 (SW062)	3.5 (SW053)		8 pCi/l¹	
Plutonium-239 ± 240	1.89 ± 0.851 (SW053)	60 ± 1 (SW053)		15 pCi/l	
Americium-241	0.03 ± 0.03 (SW053)	33 ± 1 (SW055)		30 pCi/l	
Cesium-137	1.4 ± 0.9 (SW027)	1.9 (SW062)			
Tritium	*****	1100 ± 306 (SW063)		20,000 pCi/l	500 pCi/l
Radium-226	0.3 ± 0.2 (SW054)	4.2 ± 0.6 (SW054)	5 pCi/l ⁽²⁾	5 pCi/l ⁽²⁾	
Radium-228		10 ± 2 (SW054)			
Uranium-233 ± 234	9.82 ± 0.586 (SW063)	13.8 ± 1.68 (SW064)			
Uranium-235	0.4 ± 0.1 (SW070)	0.84 ± 0.62 (SW030)			
Uranium-238	7.97 ± 0.526 (SW063)	13.0 ± 1.0 (SW054)			

⁽⁴⁾ Values as reported in Appendix C of Final Phase II Work Plan for OU No. 2 (EG&G, 1991d); rejected values were not considered.

⁽e) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990).

Colorado Department of Health/Water Quality Control Commission, Classifications and Numeric Standards for S. Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin 3.8.0(5 CCR 1002-8) 4/6/1981; amended 2/15/1990.

⁽¹⁾ Standard for strontium-90.

⁽²⁾ Standard for radium-226+228.

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(z)

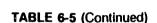
(Continued) 2-8 3JBAT

MOUND FEDERAL AND STATE SURFACE WATER QUALITY STANDARDS COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR RADIONUCLIDES TO

1\iOq 0f	,		(e20W2) 0.1 ± e.7	5.32 ± 1.44 (SW060)	Uranium-238
1\iDq 0r			(630WS) \$.0 ± 0.f	(090WS) 1.0 ± S.0	Uranium-235
1\iDq 0f			(630WS) 0.1 ± 7.7	(180WS) ES.1 ± 60.8	Vranium-233 ± 234
			(690WS) S ± 81	*****	8SS-muibsЯ
	5 pCi/I®	5 pCi/l ⁽²⁾	(630WS) \$.1 ± S.7	0.2 ± 0.2 (SW060)	82S-muibeA
500 pCi/l	20,000 pCi/l		320 ∓ 510 (2M0e0)	*****	muitin₹
·			(000WS) 8.0 ± 7.0	(090WS) 8.0 ± 8.0	7£1-muisəO
I∖i⊃q 20.	30 pCl/l		(e20W2) 1.0 ± E.1	(180WS) S0.0 ± 00.0	Americium-241
1\iOq 20.	15 pCi/I		(101WS) 10.0 ± E.E	(180WS) ££1.0 ± 801.0	04S ± 86S-muino1ul9
	⁽¹⁾ I∖i⊃d 8		(101WS) 6.0 ± 2.5	(090WS) 2.0 ± E.0	0e ± e8-muitnort2
1\iOq et		4 աւem/չւ	(101WS) 001 ± 073	(820WS) 78.4 ± 42.8	Gross Beta
1/iDq LL		15 pCi/l	(101W2) 81S ± 087	(090WS) 8	Gross Alpha
Table 2- Radionuclide Standard for South Walnut Creek	Dalan Table D Radionolide Standards	SDWA Maximum Contaminant Level	Total Concentration (I\i)	Dissolved Concentration (PCi/I)	91ylsnA
MA∃RTS [©] SQRAQNATS V		FEDERAL STANDARDS			

Standard for strontium-90. (1) Basin, Republican River Basin, Smoky Hill River Basin 3.8.0(5 CCR 1002-8) 4/6/1981; amended 2/15/1990. Colorado Department of Health/Water Quality Control Commission, Classifications and Numeric Standards for S. Platte River Basin, Laramie River EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990). Values as reported in Appendix C of Final Phase II Work Plan for OU No. 2 (EG&G, 1991d); rejected values were not considered.

Standard for radium-226+228.



COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR RADIONUCLIDES TO FEDERAL AND STATE SURFACE WATER QUALITY STANDARDS **EAST TRENCHES**

RFI/RI Work lant, Golden,				FEDERAL STANDARDS	CLAS	STATE STREA	
k Plan (Alluvial) , Colorado	Analyte	Dissolved Concentration (pCi/l) ^(a)	Total Concentration (pCi/l) ^(a)	SDWA Maximum Contaminant Level ^(b)	Basin Table D Radionuclide Standards	Table 2 Radionuclide Standard for Woman Creek	Table 2-Radionuclide Standard for South Walnut Creek
903	Gross Alpha	9.92 ± 4.51 (SW065)	138 ± 70 (SW103)	15 pCi/l		7pCi/l	11 pCi/l
Pad	Gross Beta	8 ± 4 (SW065)	140 ± 30 (SW103)	4 mrem/yr		5 pCi/l	19 pCi/l
. Mound	Strontium-89 ± 90	0.0792 ± 0.128 (SW102)	0.73 ± 0.51 (SW103)		8 pCi/l ⁽¹⁾		
Mound, and E	Plutonium-239 ± 240	0.0792 ± 0.128 (SW102)	10.541 ± 0.191 (SW065)		15 pCi/l		0.5 pCi/l
ast 1	Americium-241	0.00 ± 0.02 (SW103)	0.533 ± 0.094 (SW103)		30 pCi/l		0.5 pCi/l
renche	Cesium-137	0.3 ± 0.8 (SW065)	0.63 ± 0.64 (SW103)				
. ŭ	Tritium		563 ± 308 (SW102)		20,000 pCi/l	500 pCi/l	500 pCi/l
888	Radium-226	0.1 ± 0.3 (SW065)	6.2 ± 0.6 (SW103)	5 pCi/l ^{r2}	5 pCi/l ^{ra}		
	Radium-228	*****	7.9 ± 4.4 (SW103)				
	Uranium-233 ± 234	6.1 ± 0.6 (SW065)	9.35 ± 1.93 (SW065)				10 pCi/l
	Uranium-235	0.2 ± 0.1 (SW065)	0.7 ± 0.2 (SW065)				10 pCi/l
	Uranium-238	5.13 ± 1.20 (SW102)	6.48 ± 1.20 (SW059)				10 pCi/l

Values as reported in Appendix C of Final Phase II Work Plan for OU No. 2 (EG&G, 1991d); rejected values were not considered.

⁽b) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990).

Colorado Department of Health/Water Quality Control Commission, Classifications and Numeric Standards for S. Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin 3.8.0(5 CCR 1002-8) 4/6/1981; amended 2/15/1990.

⁽¹⁾ Standard for strontium-90.

Standard for radium-226+228.

tritium, and total radium-226 exceeded surface water quality standards. Because of these exceedences, tritium and radium-226 are likely to be potential contaminants of concern. The maximum gross alpha value may also be of concern although it is not known to what specific radionuclide(s) this value is to be attributed. Based on the following cursory literature review, however, it seems unlikely that at the low dose levels reported, sufficient sensitive methods exist to distinguish adverse biological response from background "noise" (chance fluctuations due to climate, weather, human disturbance, etc.) at the Rocky Flats Plant Site.

Terrestrial Ecosystems

Historically, the principal reason for determining BCFs for terrestrial biota was to calculate the internal radiation dose to higher trophic levels at an equilibrium body burden from radionuclides assimilated from foodstuffs. For the most part, BCFs for mammals have been collected from fallout studies under widely varied habitat conditions (arctic, desert, temperature zone, and laboratory), and, consequently, there are few consistent generalizations. Concentration factors for cesium-137 typically show an increase from plants to mammalian herbivores as well as increases at the higher trophic levels. Ninefold increases in cesium-137 through the plant → mule deer → cougar food-chain were demonstrated in the work done by Pendleton et al. (1965). Also an increase of approximately 2- to 5-fold at each link in the lichen → caribou → wolf food-chain has been reported by Hanson et al. (1967).

Less comprehensive data are available for the other radionuclides, but it is evident that not all radionuclides are concentrated in food-chains and that different food-chains may exhibit markedly different concentration patterns for the same nuclide. The strontium-90 BCF for the plant → herbivore chain ranges from 0.02 to 8.4; while the BCFs for tritium, cobalt-60, and iodine-131 are less than 1.0, with the exception of 2.4 for seed → water → quail for cobalt-60 movement (Auerbach et al., 1973).

There have been few field studies on the comparative uptake of actinides (transuranics) by biota from contaminated soils. Uranium, thorium, and plutonium transfer in terrestrial food-chains has not been well studied because of the difficulty and expense of analyzing these elements at low levels in biota and the frequent high degree of variation in field data that complicates statistical comparisons between different actinides. Field studies that have been conducted on soil-plant-animal transfer suggest that bioaccumulation of these elements does not occur. The Hakonson (1975) study of actinide levels in soils, plants, and animals indicates that, at the Trinity Site, residual plutonium was approximately 10 times lower in small rodents than in the corresponding grass samples. This same trend has been noted in other studies as well (Garten and Daklman, 1978; Garten et al., 1981). Bly and Whicker (1978) found that the mean ratio of plutonium-239 in arthropods to plutonium-239 in 0 to 3 cm soil at Rocky Flats Plant was 1:9x10⁻³.

Little et al. (1980) conducted a comprehensive study in the grassland ecosystem around Rocky Flats. The

overall conclusions mirror the previously mentioned works in that plutonium was not accumulated up through

the food-chain. Additionally, the body burdens of biota were significantly lower than required to elicit a

biological or ecological effect.

Most studies of radiosensitivities of soil fungal populations have been performed in the laboratory. Studies on

the effects of irradiation of natural populations in the field have been rare and have suffered from inadequate

controls (Stotsky and Mortenson, 1959 and Stanovic et al., 1961).

A study by Edwards (1969) revealed distinct differences in radiosensitivities of various microarthropod groups,

but all were killed at levels much lower than those lethal to microflora. Orbatid mites, the most radiation-

resistant microarthropods, were killed by 200 kilorads. Auerbach et al. (1957) found that, with lower radiation

doses, a lag effect exists in growth rates in certain microarthropods, such as Collembola. Cawse (1969) noted

that bacteria are the most tolerant to radiation up to about 2.5 megarads. Fungi are resistant up to about 1

megarad (Johnson and Osborne, 1964).

Fraley and Whicker (1973) found native shortgrass plains vegetation to be very resistant to chronic gamma

radiation at exposure rates varying from 0.01 to 650 Roentgen/hr (R/hr, usually expressed as roentgen

equivalent man-rem). One of the most resistant species was Lepidium densiflorum, which became dominant

at exposure rates of 12 to 28 R/hr and was able to germinate, develop, and complete seed set at exposure

rates greater than 28 R/hr. The level of radiation exposure in their study is many orders of magnitude greater

than any encountered in the environment around facilities such as Rocky Flats.

A long-term project was initiated in 1968 at Oak Ridge National Laboratory (Styron et al., 1975) to assess

effects of mixed beta and gamma radiation from simulated fallout on a grassland ecosystem. Extensive

statistical analyses of data on numbers of individuals collected for each of 76 arthropod and 2 molluscan taxa

have identified no lasting significant changes in similarity or species diversity of experimental versus control

communities as the result of the long-term irradiation at low doses rates. Natural fluctuations in community

dynamics obscured any possible radiation effects.

Mammal species and populations exhibit a similar resistance to chronic low-level exposures and even acute

exposures required in excess of 100 rads to elicit reproductive, hemopoietic, or survivorships responses

(Kitchings, 1978).

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Aquatic Ecosystems

Aquatic food-chain dynamics are similar to those previously described for terrestrial ones. On the whole, the

actinides have no known biological function and do not show an affinity for muscle in higher trophic level

organisms (Poston and Klopfer, 1988). In a study conducted at the Savannah River Plant by Whicker et al.

(1990), aquatic macrophytes were found to have the highest concentration ratio, primarily, the authors suggest.

due to adsorption of sediment particulate to surfaces. All other trophic levels were found to have very low

concentration ratios. In nearly all cases, concentrations of transuranics in vertebrate tissues were very low.

Because of low food-chain transfer factors for most uranics, low concentrations in water, sediments,

macrophytes, and invertebrates generally result in low concentrations of transuranics in vertebrate tissues (Bair

and Thompson, 1974; Eyman and Trabalka, 1980).

Only 5 to 10 percent of the plutonium and americium in sediments in a process waste pond on the Hanford

Reservation were found to be available for foodweb transfer (Emery et al., 1975). The remaining fraction

appeared to be tightly bound to particles and would be transported ecologically in particulate form. Watercress

had a plutonium concentration about equal to that found in the sediments, while dragonfly larvae and snails

had americium levels approximating levels in the sediments. All remaining biota had plutonium and americium

concentrations which were generally well below those of the sediments. Goldfish in the pond concentrated

small amounts of both isotopes.

With respect to the distribution of several long-lived radionuclides within aquatic ecosystems, the work of

Whicker et al. (1990) tends to confirm and strengthen the concept that many radionuclides tend to reside

entirely in the sediments. It appears that this is true for cesium-137 and the transuranium elements. The rule

also seems to hold for different types of systems with widely varying limnological properties. As a

consequence, only a very small fraction of the total system inventory can reside in the biotic components. For

radionuclides that tend to sorb strongly to sediments, this distribution can probably be extended to most

freshwater ecosystems.

6.1.2.3 Organic Compounds

Most of the organic compounds found at OU No. 2 (Table 6-1) are on the RCRA Appendix VIII and IX Lists.

the Superfund Target Compound List, and the EPA Clean Water Act Priority Pollutants Compounds List, and

each is known to cause adverse acute and chronic effects on aquatic life, depending on its concentrations.

Chemicals that are readily accumulated by aquatic biota and are persistent in aqueous media (e.g., petroleum

distillates) will require evaluation of their potential adverse effects on site-specific biota. While there is no

history of their disposal, detection of pesticides, PCBs, or dioxins in the Phase II analytical program for abiotic

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media would also warrant further consideration in this environmental evaluation. Locations of elevated levels of such organic chemicals in ground water will warrant evaluation due to the potential interaction with surface water and subsequent potential for exposure to receptor organisms.

As shown on the Table 6-6, maximum levels for some of the organic compounds (e.g., carbon tetrachloride, trichloroethene, and tetrachloroethane) were above federal MCLs and federal water quality criteria for protection of human health. Although these same values are below AWQC for protection of aquatic life, these compounds will require closer evaluation of their potential to cause adverse effects on aquatic ecosystems.

Maximum values for organic compounds in soils and sediments (Table 6-7) were compared to RFI Guidance environmental action criteria (EPA, 1989f). As these are human health-based criteria, a safety factor of 100 was applied based on the assumption that biota are 100 times more sensitive than humans. Reported maximum values in soils and sediments at OU No. 2 were well below those criteria that were available. Volatile organic compounds in soils and sediments are generally not of immediate concern insofar as causing adverse effects on terrestrial biota, due to their tendency to volatilize.

6.1.3 Protected Wildlife, Vegetation, and Habitats

6.1.3.1 Wildlife

The U.S. Fish & Wildlife Service has identified several listed endangered or threatened wildlife species which could possibly occur in the Rocky Flats Plant area. However, none is expected to occur because of lack of habitat. These species include the endangered bald eagle (*Haliaeetus leucocephalus*), the two threatened subspecies of peregrine falcon (*Falco peregrinus tundris* and *F. p. anatum*), the endangered whooping crane (*Grus americana*), and the endangered black-footed ferret (*Mustela nigripes*).

The bald eagle is primarily a winter resident around rivers and lakes, and the closest known nesting pairs are found at Barr Lake, 25 miles to the east of Rocky Flats. Although the Rocky Flats Plant Site lacks suitable bald eagle nesting habitat, bald eagles have been observed over the plant site, and one pair has been observed feeding regularly at Great Western Reservoir, located approximately 0.4 miles east of the site.

The whooping crane passes through Colorado during its spring and fall migrations. Whooping cranes blown off their migration course could use the Rocky Flats area as a night roost. These birds prefer large marshes and wetlands in broad open river bottoms and prairies. Such habitat is not present at Rocky Flats.



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TABLE 6-6

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR ORGANIC COMPOUNDS TO FEDERAL AND STATE WATER QUALITY STANDARDS 903 PAD AREA

						Federal	Federal Standards			
				CWA AWQC for Protection of Aquatic Life 14	lor Protection ic Life ^(c)	CWA Water (for Protectiv	CWA Water Quality Criteria for Protection of Human Health (c)			
Parameter	Maximum Value Reported Concentration ⁶¹	Location	SDWA Maximum Contaminant Level*	Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only	SDWA Maximum Contaminant Level Goal ^{ex}	SDWA Maximum Contaminant Level BCs ¹⁴	SDWA Maximum Contaminant Level Goal TBCs (4
Volatile & Semivolatile Organics										
Methylene Chloride	1/84 89	SW-054	,						•	
Acetone	42.0 µg/l	SW-054								
Carbon Disuffide	6.0 µ9/1	SW-064						-		
Carbon tetrachloride	1,005 µg/1	SW-050	5 49/1	35.2 mg/l ^m		400 ng/l**	6.94 µg/1**			
1-1-Dichloroethene	140.0 µg/l	SW-050								
Trichloroethene	2,500 µg/l	SW-077	5 //8/1	45 mg/l ^{t11}	21.9 mg/l ⁽¹⁾	2.7 µg/1**	80.7 µg/l**			
1-1-1-Trichloroethene	1/8/ 0.6	SW-077								
Tetrachloroethene	65.0 µg/l	SW-050	5 µg/l	5.28 mg/l ⁽¹⁾	840 µg/l ⁽¹⁾	800 ng/l*•	8.85 µ9/1**	•		
Chloroform	94.0	SW-50							-	
Toluene	12.0 µg/l	SW-030	1 mg/l	17.5 mg/l ⁽¹⁾		14.3 mg/l	424 mg/l	1 mg/l		
1,2-Dichloroethene	44.0	SW-053		-						
Carbon Tetrachloride	1,005.0 µg/1	SW-050								
Ethylbenzene	5.0 µg/l	SW-030			•					

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TABLE 6-6 (Continued) COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR ORGANIC COMPOUNDS TO FEDERAL AND STATE WATER QUALITY STANDARDS 903 PAD

						Federal	Standards			
		·		CWA AWQC of Aquat		for Protecti	Quality Criteria on of Human alth ^(c)			:
Parameter	Maximum Value Reported Concentration ^(e)	Location	SDWA Maximum Contaminant Level ^(s)	Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only	SDWA Maximum Contaminant Level Goal	SDWA Maximum Contaminant Level BCs ⁽⁴⁾	SDWA Maximum Contaminant Level Goal TBCs ¹⁴
1,2-Dichloroethene (trans)	120.0 µg/l	SW-077								
Phenol	13 µg/l	SW-027				! :			•	
2-Methyphenol	24 µg/l	SW-027				<u> </u>				
N-Nitrosodiphenylamine	160.8 µg/l	SW-028								
Bis-(2- Ethylhexylphthalate	220 µg/l	SW-027								
Anlons										
Nitrate + Nitrate- Nitrogen	3500 mg/l	SW026					,		10 mg/l	10 mg/l
Chloride	530 mg/l	SW026	250 mg/l*	,						
Sulfate	720 mg/l	SW026 SW066	250 mg/l*							
TDS	1100 mg/l	SW055	500 mg/l*	SS	SS	250 mg/l				
TSS	7600 mg/l	SW055								
Cyanide Total	0.0358 mg/l	SW054								

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TABLE 6-6 (Continued)

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR ORGANIC COMPOUNDS TO FEDERAL AND STATE WATER QUALITY STANDARDS MOUND

							Federa	al Standards			
					CWA AV Prote of Aquati	ction		uality Criteria for Human Health ^(c)			,
Paramete	P.	mum Value eported entration ^(e)	Location	SDWA Maximum Contaminant Level ^(a)	Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only	SDWA Maximum Contaminant Level Goal ⁶⁰	SDWA Maximum Contaminant Level BCs ⁽⁴⁾	SDWA Maximum Contaminant Level Goals TBCs ^{tal}
Volatile & Semi-	volatile										
Methylene Chlor	ride 4	l4 <i>μ</i> g/l	SW-060							,	
Acetone	65	5.0 µg/l	SW-101								
Carbon tetrachic	oride 60	05 µg/l	SW-059	5 µg/l	35.2 mg/l ⁽¹⁾		400 ng/l**	6.94 µg/l**			
1-1-1-Trichloroet	hene	42.0	SW-059					ļ			
Trichloroethene	26	0.0 µg/l	SW-059	5 μg/l	45 mg/l ⁽¹⁾	21.9 mg/l ⁽¹⁾	2.7 µg/l**	80.7 μg/l ^a *			
Chloroform	82	2.0 µg/l	SW-059					,			
Tetrachloroether	ne 270	0.0 <i>µ</i> g/l	SW-059	5 μg/l	5.28 mg/l ⁽¹⁾	840 ng/l ⁽¹⁾	800 ng/l**	8.85 µg/i**			
1-2-Dichloroethe	ne 56	6.0 <i>µ</i> g/l	SW-059								
Toluene	i	12.0	SW-61	1 mg/l	17.5 mg/l ⁽¹⁾		14.3 mg/l	424 mg/l	1 mg/l		
1-1-Dichloroethe	ne 13:	3.0 µg/l	SW-059								
Anions											
Nitrate + Nitrate Nitrogen	7.	5 mg/l	SW023							10 mg/l	10 mg/l

TABLE 6-6 (Continued)

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR ORGANIC COMPOUNDS TO FEDERAL AND STATE WATER QUALITY STANDARDS MOUND

						Federa	Federal Standards			
Iluvial) - 90			`	CWA AWQC for Protection of Aquatic Life (c)	ADC for ction c Life (c)	CWA Water Qu Protection of H	CWA Water Quality Criteria for Protection of Human Health			
Par Mound 2	Maximum Value Reported Concentration ⁽¹⁾	Location	SDWA Maximum Contaminant Level ^(s)	Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only	SDWA Maximum Contaminant Level Goal ^{ed}	SDWA Maximum Contaminant Level BCs (4	SDWA Maximum Contaminant Level Goals TBCs ^{td}
Chloride	160 mg/l	SW059	250 mg/l*							
Sulfate	1/6w 09	SW059 SW0101	250 mg/l*							
Phosphate	10 mg/l	SW101								
\$01 Areas	3300 mg/l	090MS	\$1/6m 009	SS	SS	250 mg/l				
нсо,	1/6m 00S	SW059			-					
Cyanide (Total)	0.0106 mg/l	SW061		-					•	
TSS	1/6m 0057	SW101								
Chlorobenzene	1/6/1	SW-060								
N-Nitrosodiphenylamine	118 µg/l	SW-023						-		

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19 August 1991 Page 6-47 **TABLE 6-6 (Continued)**

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR ORGANIC COMPOUNDS TO FEDERAL AND STATE WATER QUALITY STANDARDS EAST TRENCHES

						F	ederal Standards			
				Protectio	AWQC for n of Aquatic ife (c)		Quality Criteria for Human Health (c)			·
Parameter	Maximum Value Reported Concentration ^(a)	Location	SDWA Maximum Contaminant Level ^(a)	Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only	SDWA Maximum Contaminant Level Goal ⁶³	SDWA Maximum Contaminant Level BCs 14	SDWA Maximum Contaminant Level Goal TBCs ^{td}
Volatile & Semivolatile Organics										
Methylene Chloride	21.0 µg/l	SW-025							-	
Acetone	17.0B µg/l	SW-24								!
Carbon tetrachloride	10.0 μg/l	SW-103	5 µg/l	35.2 mg/l ⁽¹⁾		400 ng/l**	6.94 µg/l**			
Trichloraethene			5 <i>µ</i> g/l	45 mg/l ⁽¹⁾	21.9 mg/l ⁽¹⁾	2.7 μg/l**	80.7 μg/l**		İ	
Tetrachloroethene			5 μg/l	5.28 mg/l ⁽¹⁾	840 ng/l ⁽¹⁾	800 ng/l**	8.85 µg/i**	,		· ·
Toluene			1 mg/l	17.5 mg/l ⁽¹⁾		14.3 mg/l	424 mg/l	1 mg/l		
1-1-1,-Trichloroethane	9.0 µg/l	SW-103								
N-Nitrosodiphenylamine	45.B µg/l	SW-025			,					
Anlons										
Nitrate + Nitrate Nitrogen	15.5 mg/l	SW102							10 mg/l	10 mg/l
Chloride	61.3 mg/l	SW102	250 mg/l*		·			.]		

TABLE 6-6 (Continued)

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR ORGANIC COMPOUNDS TO FEDERAL AND STATE WATER QUALITY STANDARDS EAST TRENCHES

						Fe	ederal Standards			
				Protection	WQC for of Aquatic le ^(c)		Quality Criteria for Human Health ^(c)			
Parameter	Maximum Value Reported Concentration ^(a)	Location	SDWA Maximum Contaminant Level ^(s)	Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only	SDWA Maximum Contaminant Level Goal [©]	SDWA Maximum Contaminant Level BCs ^{to}	SDWA Maximum Contaminant Level Goal TBCs ^{ta}
Sulfate	132 mg/l	SW102 SW025	250 mg/l*						,	
Sulfide				•						
TDS	800 mg/l	SW103	500 mg/l*	SS	ss	250 mg/l				
Cyanide (Total)	0.0435 mg/l	SW065								
TSS	6600 mg/l	SW102								

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TABLE 6-6 (Continued)

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR ORGANIC COMPOUNDS TO FEDERAL AND STATE WATER QUALITY STANDARDS EAST TRENCHES

	Statewide StandardsCDH/WQCC (e)			CDH/WQCC Stream Segment Classification and Water Quality Standards ⁽⁶⁾						
3		Table C								
Parameter Volatile & Semivolatile Organics	Tables A, B Carcinogenic Noncarcinogenic ¹³	Acute Value	Chronic Value	Acute Value ⁽²⁾	Chronic Value ⁽²⁾	Agricultural Standard ^{ta}	Tables A, B	Table C Fish & Water Ingestion	Acute Value	Chronic Value
Volatile & Semiyolatile Organics										
Methylene Chloride										
Acetone						i I				
Carbon tetrachloride	5 μg/l	35.2 mg/l					5 µg/l		Ì	
Trichloroethene	5 μg/l	45 mg/l	21.9 mg/l				5 µg/l		ļ	
Tetrachloroethene	10 µg/l	5.28 mg/l	840 µg/l				10 <i>µ</i> g/l	800 ng/l		
Toluene	2.42 mg/l	17.5mg/l					2.42 mg/l			
Anions							,			
Nitrate + Nitrate- Nitrogen						:				
Chloride							·	,		3 µg/l
Sulfate										250 mg/l
TDS										٠,
HCO ₃										
CO3										

TABLE 6-6 (Continued)

COMPARISON OF MAXIMUM SURFACE WATER VALUES FOR ORGANIC COMPOUNDS TO FEDERAL AND STATE WATER QUALITY STANDARDS

Notes:

- (1) Criteria not developed, value presented is lowest observed effects level (LOEL)
- In the absence of specific numeric standards for non-naturally occurring organics, the narrative standard is interpreted as zero with enforcement based on practical quantification levels (PQLs) as defined by CDH/WQCC or EPA.
- (3) Table I physical and biological parameters
 - Table II inorganic parameters
 - Table III metal parameters
 - Values in Tables I, II and III for recreational uses, cold water biota and domestic water supply are not included.
- (4) All are 30-day standards except for nitrate & nitrite.
- Secondary maximum contaminant level
- ** Human health criteria for carcinogens reported for three risk levels. Value presented is the 10-5 risk level.
- (a) Phase III RFI/RI Work Plan for OU No. 1, Appendix C (EG&G, 1990n)
- EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990).
- EPA, Quality Criteria for Protection of Aquatic Life, 1986.
- EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142 and 143, Final Rule, effective July 30, 1992.
- (e) CDH/WQCC, Colorado Water Quality Standards 3.1.0 (5 CCR 1002-8) 1/15/74; amended 9/30/89 (Environmental Reporter 726:1001-1020:6/1990).
- ODH/WQCC, Classifications and Numeric Standards for S. Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin 3.8.0 (5 CCR 1002-8) 4/6/1981, amended 2/15/90.

AWQC = Ambient Water Quality Criteria

CDH = Colorado Department of Health

SDWA = Safe Drinking Water Act

TBC = To Be Considered

WQCC = Water Quality Control Commission

TABLE 6-7

COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES
FOR ORGANIC COMPOUNDS TO ENVIRONMENTAL ACTION CRITERIA
903 PAD

			Soil		
Parameter	Soil and Action Sediment Environmental Criteria ⁽²⁾ (µg/kg)	Sediment Concentration (µg/kg) ^(e) (Sample #) (Depth Interval)	Rocky Flats Alluvium Concentration (µg/kg) ^(c) (Sample #) (Depth Interval)	Colluvium Concentration (µg/kg) (Sample # - depth) (Depth Interval)	
Volatile Organics					
Chloromethane		60 (SD029)			
Acetone	8,000,000	220B (SD030)	430B (BH12987 (9.70-12.70)	110B (bh2587) (14.50-15.70)	
Ethylbenzene				780 (BH2587) (14.50-15.70)	
Chloroform	110,000	18 (SD031)		7000 (BH2587) (14.50-15.70)	
Trichloroethene	6,400	8 (SD031)			
Methylene Chloride		22b (SD027)	31.6B (BH3087) (0.00-9.00)	46.9B (BH2487) 0.00-2.43	
Toluene	-			640 (BH2587) (14.50-15.70)	
2 - Butanone				390.0 (BH0987) 6.03-6.90	
Carbon Tetrachloride				100 (BH2887) (4.85-5.90)	
1,1,1-Trichloroethane	7,000,000			47.0 (BH5787) 4.0-5.80	

TABLE 6-7 (Continued) COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR ORGANIC COMPOUNDS TO ENVIRONMENTAL ACTION CRITERIA 903 PAD

			S	Soil
Parameter	Soil and Action Sediment Environmental Criteria ^{ra} (ug/kg)	Sediment Concentration (\(\mu g/kg\)^{\(\eta)} (Sample #) (Depth Interval)	Rocky Flats Alluvium Concentration (µg/kg) ^(c) (Sample #) (Depth Interval)	Concentration (µg/kg) (Sample # - depth) (Depth Interval)
1,2 Dichloroethene (trans)				10J (BH2887) 4.85-5.90
Tetrachloroethene	1		į	10,000 (BH2587) 14.50-15.70
2-Chloroethyl vinyl ether			13J (BH3087) 11.5-17.15	
Total Xylenes				330 (BH2587) 14.50-15.70
Semivolatiles				
bis(2-Ethylhexyl)Phthalate	83,000	i	8100 (BH3087) 0.0-9.00	3,400 (BH2883) 0.90-3.75
Diethyl Phthalate	6,000,000	i	i	
di-n-Butyl Phthalate	8,000,000		3,400(BH3087) 0.00-9.00	690B(BH2487) 0.00-2.43
di-n-Octyl Phthalate		ŧ	ı	

TABLE 6-7 (Continued) **COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES** FOR ORGANIC COMPOUNDS TO ENVIRONMENTAL ACTION CRITERIA 903 PAD

			Soil			
Parameter	Soil and Action Sediment Environmental Criteria ⁽²⁾ (µg/kg)	Sediment Concentration (µg/kg) ^(b) (Sample #) (Depth Interval)	Rocky Flats Alluvium Concentration (µg/kg) ^(c) (Sample #) (Depth Interval)	Colluvium Concentration (µg/kg) (Sample # - depth) (Depth Interval)		
Anions						
Sulfide		•				
Nitrate + Nitrite - Nitrogen		8.1(SD030)	9.10(BH2087) 20.00-20.8	9(BH2587) 8.40-8085		
Cyanide, Total			10.4(BH2387) 0.00-7.5	19.8(BH2787) 0.00-4.80		

- B Present in Blank
- J Estimated below Detection Limit

TABLE 6-7 (Continued)

COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR ORGANIC COMPOUNDS TO ENVIRONMENTAL ACTION CRITERIA MOUND

			Sc	oil
Parameter	Soil and Action Sediment Environmental Criteria ^(a) (µg/kg)	Sediment Concentration (µg/kg)(b) (Sample #) (Depth Interval)	Rocky Flats Alluvium Concentration (µg/kg) ^{k)} (Sample #) (Depth Interval)	Colluvium Concentration (µg/kg) (Sample # - depth) (Depth Interval)
Volatile Organics				
Chloromethane	•			
Acetone	80,000		2,000B(BH5387) 19.50-22.00	
Toluene			30(BH5687) 8.00-9.65	
Chloroform	110,000			
Trichloroethene	64,000			
Methylene Chloride			48(BH5687) 19.50-22.00	
2 - Butanone			150(BH4387) 0.00-1.60	
1,1,1-Trichloroethane	7,000,000		190(BH4687) 17.00-17.80	
1,2-Dichloroethane	7,000,000		120(BH5487) 2.00-4.00	
Tetrachloroethene		,		
Carbon Disulfide			140B(BH4787) 8.00-9.00	

TABLE 6-7 (Continued)

COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR ORGANIC COMPOUNDS TO ENVIRONMENTAL ACTION CRITERIA MOUND

			So	bil
Parameter	Soil and Action Sediment Environmental Criteria ^(a) (µg/kg).	Sediment Concentration (µg/kg)(b) (Sample #) (Depth Interval)	Rocky Flats Alluvium Concentration (µg/kg) ^(c) (Sample #) (Depth Interval)	Colluvium Concentration (µg/kg) (Sample # - depth) (Depth Interval)
Semivolatiles				
bis(2-Ethylhexyl)Phthalate	83,000		1300B(BH5387) 2.00-3.50	
Diethyl Phthalate	6,000,000			•
di-n-Butyl Phthalate	8,000,000			
di-n-Octyl Phthalate				
Anions	·			
Sulfide			,	
Nitrate + Nitrite - Nitrogen		38.1(SD011)		
Sulfate		173(SD011)		
Chloride		210(SD011)		

B - Present in Blank

TABLE 6-7 (Continued)

COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR ORGANIC COMPOUNDS TO ENVIRONMENTAL ACTION CRITERIA EAST TRENCHES

			Soil		
Parameter	Soil and Action Sediment Environmental Criteria ⁽⁴⁾ (µg/kg)	Sediment Concentration (µg/kg) ^(b) (Sample #) (Depth Interval)	Rocky Flats Alluvium Concentration (µg/kg) ^(c) (Sample #) (Depth Interval)	Colluvium Concentration (µg/kg (Sample # - depth) (Depth Interval)	
Volatile Organics					
Chloromethane	•				
Acetone	8,000,000		2000 (BH5387) (20.60-22.60)		
Toluene			30 (BH5487) (8.00-9.65)		
Chloroform	110,000				
Trichloroethene	6,400				
Methylene Chloride			48(BH5687) (19.50-22.00)		
2 - Butanone	 ,		150 (BH4387) (0.00-1.60)		
1,1,1-Trichloroethane	7,000,000		190 (BH4687) (17.00-17.80)		
1-2-Dichloroethane			120 (BH5487) (2.00-4.00)		
Tetrachloroethene	·			•••	
Carbon Disulfide			1408 (BH4787) (8.00-9.00)		

TABLE 6-7 (Continued) COMPARISON OF MAXIMUM SOIL AND SEDIMENT VALUES FOR ORGANIC COMPOUNDS TO ENVIRONMENTAL ACTION CRITERIA **EAST TRENCHES**

			s	Soil
Parameter -	Soil and Action Sediment Environmental Criteria ^(a) (µg/kg)	Sediment Concentration (µg/kg) ^(b) (Sample #) (Depth Interval)	Rocky Flats Alluvium Concentration (µg/kg) ^(c) (Sample #) (Depth Interval)	Colluvium Concentration (µg/kg) (Sample # - depth) (Depth Interval)
Semivolatiles		,———		
bis(2-Ethylhexyl)Phthalate	83,000		1300B (BH5387) 2.00-3.50	
Diethyl Phthalate	6,000,000	***	•••	
di-n-Butyl Phthalate	8,000,000			
N-Nitrosodiphenylamine		,	370B (BH5287) 0.00-9.50	
4-Nitroaniline			1600 (BH4787) 0.00-1.40	
Anions				
Cyanide			3.9 (BH4387) 0.00-1.60	·

B - Present in Blank

Explanation of Tables:

- (m) Risk criteria are the lowest criteria reported for Health-Based Criteria for Systemic Toxicants and Carcinogens (Tables 8-6 and 8-7 in EPA, 1989f). Criteria reported in Tables 8-6 and 8-7 are reduced by 100 to provide a safety factor to biota.
- (b) Values reported in Appendix E of the Final Phase II RFI/RI Work Plan for OU No. 2 (EG&G, 1991d); values reported as either 1) analyzed but not detected or 2) rejected, were not considered.
- (c) Values reported in Appendix A of the Final Phase II RFI/RI Work Plan for OU No. 2 (EG&G, 1991d); values reported as either 1) analyzed but not detected or 2) rejected, were not considered.

The two subspecies of peregrine falcon may occasionally occur in the Rocky Flats area as they hunt for prey. Nesting preferences are high cliff sides and river gorges, both of which are absent at Rocky Flats. However, nesting sites have been recorded about 4 to 5 miles west of the site.

The historical geographic range of the black-footed ferret coincides with that of prairie dogs, a principal prey species. Although black-footed ferret populations are now extinct in the wild, large prairie dog towns sufficient to support a black-footed ferret population (>80 acres for black-tailed prairie dogs), if found at Rocky Flats, would be surveyed by approved methods (U.S. Fish and Wildlife Service, 1986).

Several additional species are of special interest to the State of Colorado because they are endangered in the state, are game species, have small and/or declining populations, or are pest/nuisance species (Colorado Division of Wildlife, 1981, 1982a, 1982b, and 1985). These species will be identified and investigated during Task 2 and will be considered in the development of on-site food webs.

6.1.3.2 Vegetation

Ten federally-listed or -proposed plant species occur in Colorado, all of which are western slope species. None of these is known or expected to occur on or near Rocky Flats. A number of candidate species for federal listing are known to occur in Jefferson and Boulder Counties, but have not been identified at Rocky Flats.

6.1.3.3 Wetlands

Numerous regulations and acts have been promulgated to protect water-related resources, including wetlands. Wetlands play an important role in ecosystem processing and in providing habitat to a variety of plant and animal species. An assessment of Rocky Flats wetlands was completed in 1989 (EG&G, 1990m); these wetlands currently fall under the jurisdiction of the U.S. Army Corps of Engineers. Wetlands occur along Woman Creek, portions of South Walnut Creek and the South Interceptor Ditch, and at Ponds B-4, B-5, C-1, and SW-103. DOE activities with a potential to impact wetlands will follow regulations designed for their protection.

6.2 ENVIRONMENTAL EVALUATION TASKS

An environmental evaluation at OU No. 2 is necessary for Rocky Flats Plant to meet the requirements of Sections 121(b)(1) and (d) of CERCLA and Section 300.430(d) of the National Oil and Hazardous Substances Pollution Contingency Plan (55 FR 8666; 3/8/1990). An environmental evaluation, in conjunction with the human health risk assessment, is required to ensure that remedial actions are protective of human health and



the environment. Guidelines for conducting this evaluation, which is also called an ecological assessment, are provided by EPA in <u>Risk Assessment Guidance for Superfund. Volume II. Environmental Evaluation Manual</u> (EPA, 1989d). Additional guidance is derived from EPA's <u>Ecological Assessments of Hazardous Waste Sites:</u>

A Field and <u>Laboratory Reference Document</u> (EPA, 1989c) and other guidance documents (Table 6-8).

The environmental evaluation is both a qualitative and quantitative appraisal of the actual or potential injury to biota other than humans and domesticated species due to contamination at OU No. 2. The environmental evaluation is intended to reduce the inevitable uncertainty associated with understanding the environmental effects of contaminants present in OU No. 2 and to give more definitive boundaries to that uncertainty during remediation.

The following plan for OU No. 2 provides a framework for the review of existing data, the conduct of subsequent field investigations, and the preparation of the contamination assessment. Methodologies for the ecological and ecotoxicological field investigations (Tasks 3 and 9) are described in the FSP presented in Subsection 6.3.

Several of the tasks presented in the following plan will require coordination between the various operable units. In order to assure an integrated effort and to provide a means for obtaining input from regulatory agencies throughout the preliminary planning and implementation tasks, a Technical Working Group will be formed. As participants in this group, representatives from EG&G, DOE, and each of the regulatory review agencies will be involved in activities such as the determination of selection criteria for contaminants of concern, key receptor species and reference areas, and decisions regarding the use of existing data.

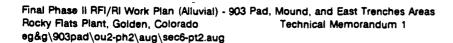
6.2.1 Task 1: Preliminary Planning

This task includes a definition of the study area, a determination of the scope of the environmental evaluation, identification of DQOs, and development of a plan for obtaining consensus on selection criteria for contaminants of concern, key receptor species, reference areas, and the field sampling approach/design. The scope of the environmental evaluation will describe the kind and amount of information that will be collected in the study. The biological parameters that are to be measured, estimated, and calculated will be described. The time period and boundaries of the evaluation will be designated. Depending on the available pathways for exposure and the habitats potentially exposed to contamination, the study area for this ecological assessment may extend beyond the boundaries of each IHSS and the 903 Pad, Mound, and East Trenches Areas.

TABLE 6-8

EXAMPLES OF EPA AND DOE GUIDANCE DOCUMENTS AND REFERENCES FOR CONDUCTING ENVIRONMENTAL EVALUATIONS

- Barnthouse, L.W., G.W. Suter, S.M. Bartell, J.J. Beauchamp, R.H. Gardener, E. Linder, R.V. O'Neill and A.E. Rosen, 1986, User's Manual for Ecological Risk Assessment. Environmental Sciences Division, Publication No. 2679, ORNL-6251.
- DOE, 1988a, Comprehensive Environmental Response, Compensation, and Liability Act Requirements, DOE Order 5400.YY., Draft, September 1988.
- DOE, 1988b, Radiation Effluent Monitoring and Environmental Surveillance, DOE Order 5400.XY, Draft, September 1988.
- DOE, 1990b, Radiation Protection of the Public and the Environment, DOE Order 5400.5
- EPA, 1988a, Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final, Office of Emergency and Remedial Response, Washington D.C., EPA/540/q-89/004.
- EPA, 1988c, Superfund Exposure Assessment Manual, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-88/001.
- EPA, 1988e, Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/2-88/003.
- EPA, 1989a, Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual, Interim Final. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89/001.
- EPA, 1989c, Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document, Office of Research and Development. EPA/600/3-89/013.
- EPA, 1989e, Exposure Factors Handbook, Office of Health and Environmental Assessment, Washington, D.C. EPA/600/8-89/043.
- EPA, 1990, Guidance for Data Useability in Risk Assessment, Office of Emergency and Remedial Response. Washington, D.C. EPA/540/G-90/008.9.2.1 Task 1: Preliminary Planning.



6.2.1.1 Selection Criteria for Contaminants of Concern

Because not all contaminants found at OU No. 2 will have adverse effects on biota, the list of chemicals to be evaluated can be narrowed. Chemical and species-specific criteria (e.g., likelihood of exposure) will be used for selecting those contaminants that are of particular concern from an ecological perspective at OU No. 2. Chemical, physical and toxicological criteria will be used in selecting contaminants of concern. Selection of these specific criteria will be developed in consultation with EPA and the State. Examples of the potential criteria to be evaluated in selecting contaminants of concern are shown in Table 6-9.

Although the selection process for contaminants of concern parallels that for the Human Health Risk Assessment, the lists may differ somewhat based on contaminant fate and transport characteristics and species-specific toxicities. The process for selecting contaminants of concern is currently being developed as an SOP. Selection of the contaminants of concern will be evaluated in accordance with EPA guidance (EPA, 1989a). An appropriate scoring system will be used to quantify the selection as much as possible. The selection process for these criteria will take into account the limited data that are available to quantify some of these factors (e.g., concentrations detected on site; frequency of detection). In these cases, a weighing as tools to help select chemicals that need further assessment. They will not be used as limits which indicate absolute "no adverse effects" levels. Actual site-specific conditions will determine the potential for adverse effects in receptor species at OU No. 2.

6.2.1.2 Identification of Key Receptors

Key receptors are those species or taxon which are or may be sensitive to the particular contaminants of concern. Organisms at each trophic level within a food web differ in their sensitivity and the ways they take in, accumulate, metabolize, distribute, and expel contaminants. The susceptibility of a particular organism also varies with the mechanism through which contaminants are taken up from the environment. In general, the following criteria determine the susceptibility of the receptor to a particular contaminant (EPA, 1989a):

- The rapidity with which the contaminant is absorbed from the environment.
- Sensitivity of the receptor's tissues to the dosage incurred.
- Relationship between tissue sensitivity and the expression of symptoms of toxic injury.
- The rapidity of repair or accommodation to the toxic injury.

Selection of key receptors will depend on the ability to detect toxic injury in the organism or subsequent adverse effects to the population. National standards on the definitions of injury to biological receptors are found in the NRDA Rule [40 CFR Subtitle A Section 11.62 (f)]. These include death, disease, behavioral

TABLE 6-9

POTENTIAL SELECTION CRITERIA FOR CONTAMINANTS OF CONCERN

Concentrations detected on site Frequency of detection Historical disposal information

- Type
- Quantity

Mobility in environmental media

Chemical fate (transport)

- Adsorption coefficient
- Partition coefficient (water-octanol)
- Water solubility
- Vapor pressure

Persistence

- Biodegradation
- Chemical degradation

Bioaccumulation potential

Bioavailability

Biotransformation potential

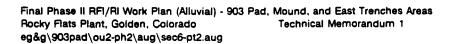
Background concentrations

Biochemistry

- Essential nutrient
- Enzyme inhibitor

Toxicity

Treatability



abnormalities, cancer, physiological malfunctions, and physical deformation. Additional methods for detecting injury to biological resources are provided in the Type B Technical Information Document: Injury to Fish and Wildlife Species (DOI, 1987). The procedures described in these documents provide a framework for determining what categories of effects might be observed in the field during the site visit and subsequent surveys and for selecting appropriate study methods to establish relationships between contaminant distribution and concentration in the physical environment and biological consequences in the receptor organisms and populations (Reagan and Fordham, 1991). By using this approach to focus efforts on examining specific effects in key receptors, costs and sampling efforts will be reduced.

The selection of key receptors is in part a subjective decision based on species dominance or judged importance in the food chain. Selection criteria for key receptors will include consideration of the following:

- Sensitivity to contaminants.
- Listing as rare, threatened, or endangered by a governmental organization.
- Game species.
- A key component of ecosystem structure and function (e.g., abundant prey for other important species).

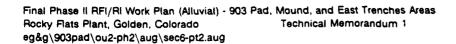
Additional criteria used in the selection of key receptors include habitat preferences, food preferences, and other behavioral characteristics which can determine population size and distribution in an area or significantly affect the potential for exposure. Key receptors may include game species such as mule deer (*Odocoileus hemionus*) which is mobile and has a large home range; or an organism that is sedentary or has a more restricted movement, such as plants, some invertebrates, and some small vertebrates. For contaminants that bioaccumulate, the effects are usually most severe for organisms at the top of the food chain (e.g., top predators). Examination of contaminant effects on these more mobile species may necessitate the integration of data from different operable units.

A checklist of OU No. 2 biota will be developed in conjunction with the ecological field inventory. The initial list of key receptors will be chosen from the checklist based on the selection criteria and will include organisms from each trophic level. The documented selection analysis will include an evaluation of the receptor's relation to potential contaminant exposure through both direct contaminant accumulation from the abiotic environment and bioaccumulation through the food chain. Examples of key receptor species (or taxon) likely to be on this list are presented in Table 6-10. This list will be refined as information is evaluated on known contaminant effects on these species (or similar species) and the documented levels of contamination present at the site.

TABLE 6-10

POTENTIAL KEY BIOLOGICAL RECEPTORS FOR ASSESSMENT OF ECOLOGICAL IMPACTS FROM OU NO. 2

Community	Taxon
Periphyton	Green algae Blue-green algae
Benthic Macroinvertebrates	Mayflies (larvae) Caddis flies (larvae) Chironomids (larvae) Crayfish
Fish	Fathead minnow Bluegill
Reptiles	Garter snake Bull snake
Mammals	Deer mouse Northern pocket gopher Microtines Rabbit Coyote
Birds	Mourning dove Mallard Killdeer Red-winged blackbird Ring-necked pheasant Cormorant Blue heron Great-horned owl
Terrestrial Invertebrates	Earthworms Grasshoppers
Grasses	Western wheatgrass Blue grama Cheatgrass
Shrubs/Forbs	Snowberry Willows Bindweed Sunflower Cattails Pondweed
Microbial Populations	Entire population



Key receptors will be selected from this list for subsequent detailed food web analyses and possible tissue sampling or other ecotoxicological analyses. Selection of key receptors for tissue analyses will depend on the receptor's suitability for sampling, sample size requirements, results of the preliminary exposure assessment, and expectation for finding contaminants in the tissues sampled (see Subsections 6.2.9 and 6.2.10). Final selection of the contaminants of concern and key receptors will provide the basis for the contamination assessment (Tasks 4 through 7). In the contamination assessment, food webs and contaminant exposure pathways will be developed for OU No. 2. Information on these food webs will be used to relate quantitative data on contaminants in the abiotic environment to adverse effects in biota and to evaluate potential impacts to biota due to contaminant exposure.

6.2.1.3 Reference Areas

Determination of criteria for selection and sampling of reference areas will be coordinated between operable units and will be addressed in the SOPs. Reference areas will be identified as needed for terrestrial, wetland, and aquatic species, and will be selected based on measurement endpoints. Reference areas are likely to be selected in the northwestern portion of Rocky Flats Plant, away from potential effects associated with releases from either Rocky Flats or OU No. 2. Additional off-site areas may also be selected, as appropriate.

Reference areas need not be selected where current and historical data is available to assess impacts from OU No. 2 contaminants. Where such data are not available, one or more reference areas may be selected based upon their similarity to OU No. 2, their lack of exposure to contamination from Rocky Flats or other sources, and the selected measurement endpoint. If more than one habitat or ecosystem type (e.g., terrestrial and aquatic) is to be assessed at OU No. 2, comparable reference areas may be established for each, or a reference area may be selected containing those habitats or ecosystem types in a comparable distribution. For OU No. 2, at least one reference area may be located upstream of the assessment area unless conditions indicate the area is unsuitable as a reference area. Data collected from the reference area(s) will be compared where possible to values reported in the scientific literature to demonstrate that the data represent a normal range of conditions. Methods used to collect data at the reference area will be comparable to those used at OU No. 2.

The decision process for using reference areas in the investigation of adverse effects from contamination at Rocky Flats is presented in Figure 6-2. As shown in this figure, a number of activities will take place prior to the selection of reference areas. These activities include the determination that:

- A pathway (inhalation, ingestion, etc.) exists for the movement of a contaminant of concern from the physical abiotic media to biota
- Acceptable methods are available to study the resultant effects of contamination at the individual, population, or ecosystem level (e.g., species diversity, trophic structure complexity.

Selection of a reference area(s) will ultimately depend on the specific effect or ecological endpoint to be measured. More than one reference area may be used depending on the effects to be studied. The selection of reference areas would be made to meet DQOs (EPA, 1989a) and the selected assessment and measurement endpoints. Two basic criteria would be employed in the selection and establishment of reference areas:

- The reference areas will be similar to OU No. 2 in terms of soil series, topography, aspect, vegetation, habitat types, and plant and animal assemblages.
- The reference areas, including vegetation and wildlife, have not been impacted by releases from OU No. 2 or other Rocky Flats Plant operable units.

6.2.1.4 Data Quality Objectives

The DQO development process will follow the three steps recommended by EPA (1989c). Step I of the DQO process involves preparing definitions and concise DQOs. Examples of Step I program DQOs for this environmental evaluation include the following:

- Identify appropriate site-specific receptor species, contaminants of concern, and exposure
 pathways to determine if there is a potential for adverse effects to occur as a result of
 contamination. This step includes determination of relevant contaminant concentrations in
 biological tissues.
- Evaluate the potential for impacts to occur to biological resources outside the boundaries of OU No. 2 or Rocky Flats Plant.
- Evaluate the need for remediation to protect the environment.

Steps II and III of the DQO process include identification of data uses and needs and design of the data collection program. Products of Step II include proposed statements of the type and quality of environmental data required to support the DQOs, along with other technical constraints on the data collection program. The objective of Step III is to develop data collection plans that will meet the criteria and constraints established in Steps I and II. Step III results in the specification of methods by which data of acceptable quality and quantity will be obtained. The DQO development process will continue as scoping of the environmental evaluation becomes more refined. Additional Step I decision-type DQOs may be needed, or data collection-type DQOs may be modified based on Task 1 and Task 2 results and subsequent refinement of the field sampling plan.

6.2.1.5 Field Sampling Approach/Design

The FSP presented in Subsection 6.3 is designed to be flexible, so that it can be revised as additional data are collected. Flexibility in the FSP will ensure that field data collection activities will be comparable to and

compatible with previous data collection activities performed at the site, while providing a mechanism for planning and approving new field activities. The FSP, in conjunction with SOPs for Ecology (Volume V-in preparation by EG&G), will provide guidance for all field work by defining the sampling and data-gathering methods to be used on the project.

6.2.2 Task 2: Data Collection/Evaluation and Conceptual Model Development

As an integral part of the RFI/RI process, Task 2 of the environmental evaluation will focus on accumulating and analyzing pertinent information on three major areas:

- Species, populations, habitats and food web interrelationships.
- Types, distribution, and concentrations of contaminants in the abiotic environment (e.g., soil, sediments, surface water, ground water, and air).
- Preliminary determination of potential exposure pathways and potential contaminant effects on OU No. 2 biota based on literature review.

The principal subtasks in Task 2 include Literature Review and Site Characterization. These subtasks will be performed in conjunction with Task 3, Ecological Field Investigation. Information that will be developed from these tasks includes the following:

- Chemical Inventory/Contaminants of Concern Existing information including that obtained on chemical contaminants from other investigations at Rocky Flats and other DOE facilities will be used in the development of a preliminary list of contaminants of concern.
- Initial toxicity test data Preliminary data on the toxicity of potentially complex chemical mixtures in OU No. 2 surface waters.
- Descriptive field surveys Inventory of OU No. 2 biota and locations of obvious zones of chemical contamination, ecological effects, and human disturbance.
- Species inventory Plant and animal species known to occur within OU No. 2 or to potentially contact contaminants at OU No. 2 and their trophic relationships.
- Population characteristics Information on the abundance of key species (see SOPs).
- Food habit studies Available information from literature sources to supplement field observations and possible gut content analysis on key receptor species.

6.2.2.1 Literature Review

As an essential part of Task 2, a review of available documents, aerial photographs, and data relevant to the site will be completed. This will allow compilation of a database from which to determine data gaps and to



provide evidence for a defensible field sampling program. Prior studies by DOE and the Rocky Flats Plant operating contractors will be reviewed and evaluated. Information to be reviewed will include the following:

- Project files maintained by Rockwell International and EG&G.
- Project reports and documents on file at the Front Range Community College Library, at the Colorado Department of Health, and at the Colorado Division of Wildlife.
- DOE documents and DOE orders.
- The Phase I database.
- The Rocky Flats EIS database.
- Data from ongoing environmental monitoring and NPDES programs.
- Studies conducted at Rocky Flats on radionuclide uptake, retention, and effects on plant and animal populations.
- Scientific literature, including ecological and risk assessment reports, from other DOE facilities (Oak Ridge National Laboratory, Los Alamos, Hanford, Savannah River, Fernald).

If available and applicable, historical data will be used. Where the same methods are not used in the collection of new data, use of historical data will depend on the demonstrated comparability of the data collection methods. Where possible, analytical data files will be made available in an electronic file format.

6.2.2.2 Site Characterization

Environmental resources at the site will be characterized based on reviews of existing literature and reports, including results from the Phase I RFI/RI investigation, other operable unit RFI/RI investigations and the Task 3 ecological field investigation. The description of the site will be presented in terms of the following distinct resource areas:

- Meteorology/air quality
- Soiis
- Sediments
- Geology
- Surface and groundwater hydrology
- Terrestrial ecology
- Aquatic ecology
- Protected/important species and habitats

The purpose of the site characterization is to describe resource conditions as they exist without remediation.

The narrative with supporting data will include descriptions of each resource, with attendant tables and figures,

as appropriate, to depict, in a concise and clear fashion, site conditions, particularly as they influence

contaminant fate and transport.

Included in this task is the development of a community food web model (Reagan and Fordham, 1991) to

describe the feeding relationships of organisms at Rocky Flats Plant. Food web construction begins with

gathering information to evaluate the food habits of species or species groups (e.g., grasshoppers) found or

potentially occurring on site. Standard computer searches will be augmented with searches of local university

libraries to locate any regionally pertinent studies on food habits. The preliminary list of important species,

compiled from background information, will be completed based on observations of presence and abundance

made during the ecological site surveys and on trophic level data obtained from the food web model. Based

on the model, a modified list of species will be made using toxicological information (toxicity assessment) to

determine which species or species groups might be most affected or most sensitive to the chemical(s) of

interest.

Data from past studies and preliminary data from current environmental studies will be used to better define

the present distribution of contaminants in the abiotic environment and to develop an initial food web model.

The food web model in conjunction with a preliminary pathways analysis will identify likely or presumed

exposure pathways or combinations of pathways and receptor species at risk. Based on this preliminary

information, the Task 3 and Task 9 field investigation sampling approach/designs may be revised.

6.2.3 Task 3: Ecological Field Investigation

The Phase I field investigation for OU No. 2 consists of the following separate programs: (1) the air quality

monitoring program, which will entail emissions estimation and modeling; (2) the soils, surface water, and

ground-water sampling programs, which will be conducted as part of the Phase II RFI/RI activities; (3) and the

terrestrial and aquatic biota sampling program, which will be conducted as part of this environmental

evaluation.

6.2.3.1 Air Quality

A site-wide air quality monitoring program is being conducted at Rocky Flats (Section 2.3.6 in EG&G, 1990n).

Specific air monitoring is also being done at OU No. 2. These data can be used to model airborne deposition

and transport of contaminants through the food web to potential receptors. Such modeling could be

performed where data in abiotic media are inadequate. Where the inhalation pathway is considered to be

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significant in the case of OU No. 2 biota, a detailed pathways analysis and assessment of potential adverse

effects using transport model data will be performed.

6.2.3.2 Soils

Site-specific soil data in the form of contaminants present in surficial deposits currently exist for the 903 Pad.

Mound, and East Trenches Areas (Volume II, Appendix A, Draft Final Phase II RFI/RI Work Plan, EG&G, 1991d).

These data were collected as part of Phase I of the RFI/RI for 903 Pad, Mound, and East Trenches Areas. The

drilling was conducted to identify and characterize past waste disposal sites. Boreholes were drilled within and

adjacent to the IHSSs, and soil samples were collected and analyzed for organics, inorganics, metals, and

radionuclides. Sequences of Rocky Flats Alluvium, colluvium, recent valley fill, and Arapahoe Formation were

sampled and tested in the field and in the laboratory. The geologic and hydrologic data from Phase I drilling

programs provided the basic framework for defining a chemical/hydrologic/geologic model for the 903 Pad,

Mound, and East Trenches Areas. Source contaminants and concentrations, as well as possible flow paths,

rates, and accumulations, were preliminarily assessed to characterize the dynamic system.

Volatile organics data for soils previously collected from the 903 Pad, Mound, and East Trenches Area area

were rejected during the data validation process because of inadequate sample size and cannot be used in

a quantitative sense. Analytical results of the Phase I soil samples will be reviewed and interpreted for use in

this environmental evaluation.

The Phase II RFI/RI work plan proposes an additional soil sampling program for the 903 Pad, Mound, and East

Trenches Areas to further characterize the extent of contamination, gain additional hydrologic data, and resolve

questions regarding the presence and concentration of volatile organics. Under the program, test wells will

be designed to provide a continuous core of sediment, and will evaluate the Rocky Flats Alluvium, colluvium,

Recent valley fill, and upper section of the Arapahoe Formation. Soil samples will be analyzed for organics,

inorganics, metals, and radionuclides.

As in prior programs, the soil sampling locations are placed in areas to characterize specific sites and

regimens, and they do not form a random grid. However, sample density is considered sufficient to provide

a clear picture of soil characteristics and contaminant concentrations for all soil types found in the 903 Pad.

Mound, and East Trenches Areas. The range of substances to be tested (from the Hazardous Substance List)

is also considered sufficient for the environmental evaluation.

Soil analysis results are related to surface and groundwater regimens. Fluids moving through the soils can act to leach contaminants and transport them through available flow paths and deposit them in downgradient environments. Soil analyses may help define extent of contaminant sources as well as areas of accumulation.

The near surface soil scrapings will be of prime importance for determining source contaminants for biota. This uppermost layer provides the major source of nutrient and contaminant uptake for the vegetation under study and is a source of potential contaminant ingestion to wildlife. Sampling and analysis programs proposed under the Phase II RFI/RI field investigation will be reviewed by the Technical Working Group and modified as necessary to ensure that sampling intervals, methods, and the analytical program are appropriate and meet DQOs of the environmental evaluation.

6.2.3.3 Surface Water and Sediments

The proposed Phase II surface water sampling and analytical program presented in the RFI/RI Work Plan for 903 Pad, Mound, and East Trenches Areas was evaluated with respect to this environmental evaluation. Sampling locations presented in the work plan are continuing to be sampled on a monthly basis through 1990 as part of the overall plant sampling program. All seeps and springs in the 903 Pad, Mound, and East Trenches Areas will be sampled as part of this ongoing program. Chemical results from the surface sampling locations will be reviewed and incorporated into the environmental evaluation.

Surface water and sediment samples are collected on a regular basis as part of ongoing investigations at OU No. 2 as well as nearby OU Nos. 1 and 5. The proposed investigation at OU No. 2 includes extensive sampling along Woman Creek, South Walnut Creek, the SID, and in Ponds B-4, B-5, C-1 and C-2. In addition, samples will be collected upstream of the Rocky Flats Plant to provide background data. Samples will be analyzed for metals, radionuclides, inorganics, and organics. Total organic carbon in soils and sediments and sediment grain size will be determined as part of the analytical program.

Surface water sampling and analytical results presented in the Final Phase II OU No. 2 RFI/RI Work Plan will be evaluated with respect to the abiotic sampling programs planned in the nearby operable units to assure the abiotic data needs for the environmental evaluations at each of these operable units are addressed. Sampling locations and programs presented in each of these work plans will be integrated as part of the field sampling implementation program. Chemical results from the OU No. 1 and OU No. 5 surface sampling locations will be reviewed and incorporated into the OU No. 2 environmental evaluation as needed.

6.2.3.4 Ground Water ...

The Phase II RFI/RI Work Plan for the 903 Pad, Mound, and East Trenches Areas provided a detailed

discussion of the planned Phase II ground-water investigation and summarized the scope and results of

previous Phases I ground-water studies conducted in 1987. The results of the Phase I investigations, along

with planned Phase II activities for the 903 Pad, Mound, and East Trenches Areas, were reviewed to determine

if any data gaps existed and should be resolved prior to implementing the Phase II program and environmental

evaluation for the 903 Pad, Mound, and East Trenches, Areas.

Data from the Phase II program will aid in characterizing the nature and areal extent of ground-water

contamination in the vicinity of the site. The hydrogeologic information and laboratory analytical results from

the planned Phase III boring and well installation program will likewise be used in the environmental evaluation.

The above information will be used to assess the nature and extent of contamination in shallow ground water

and help identify exposure pathways for the environmental assessment.

Data from the Phase I OU No. 5 RFI/RI Program and the Phase III OU No. 1 RFI/RI Program will also aid in

characterizing the nature and areal extent of ground-water contamination in the vicinity of the site. The

hydrogeologic information and laboratory analytical results from these planned boring and well installation

programs will likewise be incorporated in the OU No. 2 environmental evaluation where applicable. The

information will be used to assist in determining the nature and extent of contamination in shallow ground-water

and help identify exposure pathways for the environmental assessment.

6.2.3.5 Terrestrial and Aquatic Biota

Terrestrial and aquatic species in the Rocky Flats Plant area have been described by several researchers

(Weber et al., 1974; Clark, 1977; Clark et al., 1980; Quick, 1964; Winsor, 1975; CDOW, 1981; CDOW, 1982a,

1982b); most of these reports are summarized in the Final EIS (DOE, 1980). In addition, terrestrial and aquatic

radioecology studies conducted by CSU and DOE (Rockwell International, 1986f; Paine, 1980; Johnson et al.,

1974; Little, 1976; Hlatt, 1977), along with annual monitoring programs at Rocky Flats Plant, have provided

information on the plants and animals in the area and their relative distribution.

Limited field surveys will be conducted in Task 3 to characterize current biological site conditions in terms of

species presence, habitat characteristics and/or community organization. The emphasis will be to describe

the structure of the biological communities at OU No. 2 in order to identify potential contaminant pathways,

biotic receptors, and key species.

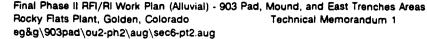
Initial aquatic toxicity tests using Ceriodaphnia spp. and fathead minnows will be conducted at OU No. 2 under Task 3. The technical objective of the toxicity tests is to provide a screening mechanism to aid in the determination of the nature and extent of contamination, particularly since there is the potential for exposure to mixtures of contaminants. EPA recognizes the usefulness of such toxicity testing as a means for integrating the effects of all toxic pollutants, which cannot be measured by chemical analysis. Standardized EPA acute and chronic test methods will be followed in accordance with NPDES toxicity testing procedures currently being used at Rocky Flats.

Vegetation

The objectives of the vegetation sampling program are to provide data for: (1) the description of site vegetation characteristics; (2) identification of potential exposure pathways from contaminant releases to higher trophic-level receptors; (3) selection of key species for contaminant analysis to determine background conditions for OU No. 1; and (4) identification of any protected vegetation species or habitats. A number of habitat types are expected to be found in the 903 Pad, Mound, and East Trenches Areas. Grasses characteristic of the short grass plains are expected to be abundant. Representative species include blue grama (Bouteloua gracilis), Junegrass (Koeleria cristata), dropseed (Sporobolus spp.), slender wheatgrass (Agropyron trachycaulum), and green needlegrass (Stipa viridula), which are interspersed with other grasses, shrubs, and a variety of annual flowering plants. Transects will be established on the 903 Pad, Mound, and East Trenches Areas (see Section 6.3.2.1) to collect phytosociological data on biomass and cover, shrub/tree density and frequency, and species presence.

Wetland Vegetation

Wetlands have been identified along Woman Creek, South Walnut Creek, the SID, and Ponds B-4, B-5, C-1, and C-4 (EG&G,1990m). These occur as linear wetlands that support hydrophytic vegetation species including sandbar willow (Salix exigua), american watercress (Barbarea orthoceras), and plains cottonwood (Populus sargentii). Other species associated with these wetlands include broad-leaf cattail (Typha latifolia), baltic rush (Juncus articus), cordgrass (Spartina pectinata), silver sedge (Carex praegracilis), and various bulrushes (Scirpus spp.). Transects will be established in adjacent wetland vegetation habitats at the designated aquatic sampling locations (see Section 6.3.2.2) to collect phytosociological data on biomass and cover, shrub density and frequency, and species presence.



Periphyton

The periphyton community is a closely-adhering group of organisms that form mat-like communities on rocks.

other solid objects, or the stream bottom. The community is composed of algae, bacteria, fungi, detritus, and

other macroscopic heterotrophic organisms. Because of the large surface-to-volume ratio of its constituents,

periphyton have been found to be an excellent indicator community for accumulation of contaminants.

Periphyton samples will be collected at designated locations presented in the FSP (see Section 6.3.2.2).

Periphyton communities provide a sensitive mechanism to detect changes in aquatic environments that result

from the introduction of contaminants. Taxonomic composition and relative abundance of periphyton can be

measured on natural substrates as well as standardized artificial substrates. On hard artificial substrates, data

on algal abundance, biomass, and species composition will be obtained by removing the substrate and by

scraping or brushing the flora from a measured area into a container.

Benthic Macroinvertebrates

Benthic macroinvertebrates may exist in rocky/gravelly substrates or as soft-bottom communities along

portions of Woman Creek, South Walnut Creek, the SID and Ponds B-4, B-5, C-1 and C-2. The soft-bottom

benthos are those macroscopic invertebrates inhabiting mud or silt substrates, whereas the immature stages

of insects inhabit rock surfaces, rooted stems, and leaves or gravelly substrates. Because these communities

are essentially stationary, they are good indicators of past and present habitat contamination. Additionally, their

feeding methods (filtering microscopic organisms and fine materials, preying on smaller invertebrates, and

grazing on periphyton), suggest that benthic species are ingesting other organisms that are potentially

concentrating contaminants. Designated locations (see Section 6.3.2.2) in South Walnut Creek, the SID,

Woman Creek, and Ponds B-4, B-5, and C-1 will be sampled for benthic organisms.

<u>Fish</u>

Fish can be important components of ecological assessments because they are relatively long-lived, occupy

upper trophic levels of aquatic ecosystems, and they may spend their entire lives in relatively small areas. Fish

species representing both herbivores and carnivores are likely present in the Woman Creek Drainage, South

Walnut Creek, and Ponds B-4, B-5, and C-1 aquatic habitats and may demonstrate biomagnification of

contaminants within the pond or creek ecosystem. Designated aquatic sampling locations (see Section 6.3.2.2)

will be sampled for fish where the habitat is appropriate.

Final Phase II RFI/RI Work Plan (Alluvial) - 903 Pad, Mound, and East Trenches Areas Rocky Flats Plant, Golden, Colorado Technical Memorandum 1 Terrestrial Wildlife

A field survey will be conducted to gather data on animal communities in the 903 Pad, Mound, and East

Trenches Areas. The objective of the animal life survey is to: (1) describe the existing animal community in

the 903 Pad. Mound, and East Trenches Areas: (2) identify potential contaminant pathways through trophic

levels; (3) develop food web models including contribution from vegetation; (4) identify key species for

potential collection and tissue analysis; and (5) identify any protected species.

The field survey as presented in the FSP (see Section 6.3) will document the presence of terrestrial species

and allow for a general description of the community. Some species (e.g., songbirds, larger mammals, reptiles,

and raptors) may use the area daily, seasonally or sporadically, or wander through as vagrants. Survey timing

and techniques will consider these uses.

6.2.4 Contamination Assessment (Tasks 4 through 7)

The contamination assessment includes Tasks 4 through 7. The two major objectives of the contamination

assessment are to:

Obtain quantitative information on the types, concentrations, and distribution of contaminants

in selected species.

Evaluate the effects of contamination in the abiotic environment on ecological systems.

Conducting a contamination assessment requires an evaluation of chemical and radiological exposures and

the subsequent toxicological effects on key species. Of specific importance in the contamination assessment

is the identification of exposure points, the measurement of contaminant concentrations at those points, and

the determination of potential impacts or injury. Impacts may result from movement of contaminants through

ecological systems or from direct exposure (inhalation, ingestion, or deposition).

The Contamination Assessment for OU No. 2 will be based on existing environmental criteria, published

toxicological literature, and existing, site-specific environmental evaluations. The program design will be

integrated with other ongoing RFI/RI studies so that concentrations of contaminants in abiotic media can be

related to contaminant levels and effects in biota. A preliminary contamination assessment will be made in

Task 2 based on the site characterization and contaminant identification activities. The preliminary Task 2

assessment will be used to revise the Task 9 ecotoxicological field investigation sampling design. The

contamination assessment process described in the following tasks will include the development of a site-

specific pathways model to quantify the potential for contaminant exposure and adverse effects in biota.

The objectives and description of work for each of the contamination assessment tasks is described below.

Technical Memorandum 1

Final Phase II RFI/RI Work Plan (Alluvial) - 903 Pad, Mound, and East Trenches Areas Rocky Flats Plant, Golden, Colorado eg&g\903pad\ou2-ph2\aug\sec6-pt2.aug

6.2.5 Task 4: Toxicity-Assessment

This assessment will include a summary of the types of adverse effects on biota associated with exposure to

site-related chemicals, relationships between magnitude of exposures and adverse effects, and related

uncertainties for contaminant toxicity, particularly with respect to wildlife. Ecological receptor health effects

will be characterized using EPA-derived critical toxicity values when available in addition to selected literature

pertaining to site- and receptor-specific parameters.

The toxicity assessment will provide brief toxicological profiles centered on health effects information on wildlife

populations. The profiles will cover the major health effects information available for each contaminant of

concern. Data pertaining to wildlife species will be emphasized, and information on domestic or laboratory

animals will be used when wildlife data are unavailable. Adequacy of the existing data base will also be

evaluated as part of this task.

6.2.6 Task 5: Exposure Assessment and Pathways Model

This task will identify the exposure or migration pathways of the contaminants, taking into account

environmental fate and transport through both physical and biological means. Each pathway will be described

in terms of the chemical(s) and media involved and the potential ecological receptors. The exposure

assessment process will include the following three subtasks:

Identify exposure pathways.

Determine exposure points and concentrations.

Estimate chemical intake for receptors.

Each of these subtasks is described below.

6.2.6.1 Exposure Pathways

The purpose of this subtask is to qualitatively identify the actual or potential pathways by which various

biological receptors at or near OU No. 2 might be exposed to site-related chemicals or radionuclides. The

exposure pathway analysis will address the following four elements:

A chemical/radionuclide source and mechanism of release to the environment.

An environmental transport medium (e.g., soil, water, air) for the released chemical/

radionuclide.

- A point of potential biological contact with the contaminated medium.
- A biological uptake mechanism at the point of exposure.

All four elements must be present for an exposure pathway to be complete and for exposure to occur. Exposure pathways will be evaluated and modeled, where possible, using the pathways approach (Reagan and Fordham, 1991; Thomann, 1981).

The pathways approach uses a bioaccumulation model of contaminant transfer through a food web. The model links contamination in soil and water to contamination in biota. The pathways model approach blends standard environmental assessment methods with ecological and toxicological modelling to produce an integrated procedure to selecting indicator species and conducting an investigation of ecosystem effects resulting from contamination in soil and water. Where possible, uncertainty in the model is reduced by direct sampling (i.e., tissue analyses).

Toxicity tests, such as those proposed for Task 3, can also be used to conduct a direct effects-related investigation. Additional toxicity tests may be designed based on the pathways model results.

6.2.6.2 Determination of Exposure Points and Concentrations

The identified exposure points are those locations where key ecological receptor species may contact the contaminants of concern. Potential for exposure depends on characteristics of the contaminant, the organism, and the environment. Determination of exposure points entails an analysis of key receptor species, locations, and food habits in relation to potential contaminant exposure both through direct contaminant accumulation or deposition from the abiotic environment and through indirect bioaccumulation. The exposure assessment for OU No. 2 will provide information on the following:

- What organisms are actually or potentially exposed to contaminants from OU No. 2.
- What the significant routes of exposure are.
- What amounts of each contaminant organisms are actually or potentially exposed to.
- Duration of exposure.
- Frequency of exposure.
- Seasonal and climatic variations in conditions which are likely to affect exposure.
- Site-specific geophysical, physical, and chemical conditions affecting exposure.

A determination of the nature and extent of contamination in the abiotic media (air, soils, surface water, and ground water) is presented in the Phase II RFI/RI Work Plan for the 903 Pad, Mound, and East Trenches Areas



(EG&G, 1991a). Phase-I data, where available and validated, will be summarized and used to characterize source areas and release characteristics at the site. The exact exposure points can be expected to vary depending on both the contaminant and the key receptor species under consideration.

Concentrations of chemicals that are likely to have the greatest impact (based on concentration in the environment, toxicity values, and biological uptake) will be determined by actual environmental media sampling for each exposure point or by environmental fate and transport modeling. Fate, transport, and endpoint contamination levels in abiotic media may be modeled where necessary using environmental multi-media risk assessment models. Such models can provide the potential maximum concentrations of chemicals at the exposure points by which to evaluate the "worst-case" scenario.

6.2.6.3 Estimation of Chemical Intake by Key Receptor Species

This step includes an evaluation of key receptor species' contaminant uptake by direct routes (i.e., inhalation, ingestion, dermal contact) and indirect routes (bioconcentration, bioaccumulation, biomagnification). The amounts of chemical and radiological uptake will be estimated using appropriate conservative assumptions, site-specific analytical data on contaminant concentrations in abiotic and biotic media, and forthcoming guidance from EPA's Wildlife Exposure Factors Handbook (to be published in 1991). The pathways analysis model (Reagan and Fordham, 1991; Thomann, 1981) will be used to establish relationships between concentrations of a chemical in different media with concentrations known to cause adverse effects.

Direct measurement of contaminant uptake through tissue analyses will be conducted during Task 9 of the environmental evaluation. Such site-specific data and field observations will be used to reduce uncertainty in the pathways model and strengthen interpretation of the overall study.

6.2.7 Task 6: Contamination Characterization

Contamination characterization entails the integration of abiotic exposure concentrations and reasonable worst-case assumptions with the information developed during the exposure and toxicity assessments to characterize current and potential adverse biological effects (e.g., death, diminished reproductive success, reduced population levels, etc.) posed by OU No. 2 contamination. The potential impacts from all exposure routes (inhalation, ingestion, and dermal contact) and all media (air, soil, ground water, and surface water/ sediment) will be included in this evaluation as appropriate according to EPA guidance (EPA, 1989a).

Characterization of adverse effects on receptor species and their populations is generally more qualitative in nature than characterizing human risks. This is because the toxicological effects of most chemicals have not

been well documented for most species. Criteria or toxicological benchmarks that are usable and applicable for the evaluation of ecological effects are generally limited. EPA AWQC and Maximum Allowable Tissue Concentrations (MATC) are the most readily available criteria. Criteria found in federal and Colorado state laws and regulations pertaining to the preservation and protection of natural resources can also be used. Criteria may also be derived from information developed for use under other environmental statutes, such as the Toxic Substances Control Act or the Federal Insecticide, Fungicide and Rodenticide Act. An attempt will be made to consider the adverse effects of chemicals on populations and habitats rather than on individual members of a species according to EPA guidance (1989a and 1989c). Where specific information is available in the published literature, a more quantitative evaluation of effects will be made using the site-specific pathways model. This approach is in agreement with EPA guidance (EPA, 1989a).

6.2.8 Task 7: Uncertainty Analysis

The process of assessing ecological effects is one of estimation under conditions of uncertainty. Understanding the effects of environmental stresses resulting from contamination on real populations depends on complex abiotic and biotic processes that cannot be reproduced in the laboratory. To address uncertainties, the OU No. 2 environmental evaluation will present each conclusion, along with the issues that support and fail to support the conclusion, and the uncertainty accompanying the conclusion. Factors that limit or prevent development of definitive conclusions will also be discussed. In summarizing the assessment data, the following sources of uncertainty and limitations will be specified:

- Variance estimates for all statistics.
- Assumptions and the range of conditions underlying use of statistics and models.
- Narrative explanations of other sources of potential error.

Validation and calibration of the pathways model will also be used where practicable.

6.2.9 Task 8: Planning

Task 8 will include planning for tissue analysis studies and any additional ecotoxicological studies (e.g., reproductive success, enzyme analyses, microbial respiration) needed to assess adverse effects from the contaminants of concern on key receptors. Initial designing for the Task 9 ecotoxicological field investigations will begin after contaminants of concern and key receptors have been selected in Task 2. Species to be sampled for tissue analyses will be designated to the earliest extent possible in order to avoid a duplication of the Task 3 sampling effort.

The need for measuring additional ecotoxicological endpoints in Task 9 will be evaluated based on the pathways analyses and published information on direct toxic effects. Selection of field methodologies will be based on a review of available scientific literature providing quantitative data for the species of concern or similar test species. Analysis of population, habitat, or ecosystem changes will be based on species or habitats that represent broad components of the ecosystem or are especially sensitive to the contaminants. In order to select methodologies for the ecotoxicological field sampling program, the biological response under consideration and the proposed methodology should satisfy program DQOs as well as the following more specific criteria:

- The biological response is a well-defined, easily identifiable, and documented response to the designated contaminant(s) of concern (i.e., methodology and measurement endpoint are appropriate to the exposure pathway).
- Exposure to the contaminant is known to cause the biological response in laboratory experiments or experiments with free-ranging organisms.
- Methodology is capable of demonstrating a measurable biological response distinguishable from other environmental factors such as weather or physical site disturbance.
- The biological response can be measured using a published standardized laboratory or field testing methodology.
- The biological response measurement is practical to perform and produces scientifically valid results (e.g., sample size is large enough to have useful power and small Type I error).

Tissue studies to document site-specific contamination will be conducted in Task 9 for both aquatic and terrestrial systems. Tissue analyses will be conducted on selected species from OU No. 2 and reference areas (if necessary) to document current levels of specific target analytes. Information from the Task 2 data evaluation and Task 3 field survey will determine the species and contaminants to be tested and the methods to be used. Selection of the target analytes, species, and tissues will depend on an initial determination as to which contaminants are likely to adversely impact biota and which contaminants are likely to be present in concentrations sufficient for detection.

Acute and chronic aquatic toxicity tests using fathead minnows and *Ceriodaphnia spp.* are proposed for Task 3 (see Subsection 6.3.5). These simple screening tests will provide an initial determination of the toxicity of potentially complex chemical mixtures in Woman Creek, South Walnut Creek, the SID, and Ponds B-4, B-5, and C-2. If toxicity is observed in either the acute or chronic tests at any one station, then a supplemental toxicity testing program in conjunction with physical and chemical analyses of the water and sediment may be designed for that location to determine the potential extent of the toxicant(s).

Toxicity testing methods are available for terrestrial ecosystems using microbes, earthworms, crickets, and grasshoppers (EPA, 1989a). The need for such tests will be evaluated based on the above criteria as part of this planning process.

Prior to conducting Task 9 studies, the field sampling plan will be refined to address the proposed methodologies. More specific DQOs will be formulated based on the proposed methodologies and will address the following:

- The number and types of analyses to be run.
- The species, locations, and tissues to be sampled.
- The number of samples to be taken.
- The detection limits for contaminants.
- The acceptable margin of error in analyzing results.

6.2.10 Task 9: Ecotoxicological Field Investigations

Tissue analyses will comprise most of the Task 9 ecotoxicological field investigation. Because individuals and species accumulate contaminants differentially in their tissues depending on the exposure route and form of the contaminants, environmental concentrations and general uptake rates will not necessarily predict biotic concentrations or adverse effects. Tissue analyses will be conducted to measure the total concentration of specific chemical compounds in key receptor species. By comparing tissue analysis results to toxicological benchmark concentrations (e.g., LC50 or MATC values), the potential for adverse effects in a population can be characterized. Analysis of tissue contaminant concentrations will also provide data to confirm the predicted relationship, if any, between environmental concentrations and the amount of contaminants accumulated in receptor species.

Selection of the species and specific tissues for analysis will be based on a preliminary evaluation of site-specific food webs, potential contaminant transport pathways, and potential for bioaccumulation, bioconcentration, and biomagnification. The decision process for conducting tissue analyses is presented in Figure 6-3. Tissue sampling will only be conducted for those contaminants of concern that bioaccumulate in tissue. Whole bodies or specific tissues will be analyzed depending on which portion is consumed by higher trophic level organisms. Suitability of the species for sampling and sampling size requirements will largely determine the species to be selected for tissue analysis.

To the extent possible, tissue samples will be collected simultaneously with environmental media samples (see Section 5.0 of the RFI/RI Work Plan (EG&G, 1991d). This will allow for a determination of site-specific BCFs.

These BCFs will be incorporated into the final exposure assessment and will be used to calibrate/validate the pathways model. Where BCFs cannot be determined, published or predicted BCF values will be used in the

pathways model to assess potential impacts.

For contaminants of concern that bioaccumulate, the acceptable concentration (i.e., ARAR) in the physical

environment (e.g., water) may be below reliable detection limits measurable by direct methods. For example,

the chronic AWQC for protection of aquatic life for DDT is 1.9 nanograms per liter, while the detection level

using gas chromatography is 0.1 micrograms per liter. In these instances, indicator species would be sampled

as indirect indicators of contaminant concentrations in the physical media that bioaccumulate.

Where ARARs (i.e., acceptable levels in receptor species or next lowest prey species) are established, tissue

sampling need only be conducted on site and not in the reference areas. Where no applicable ARARs exist,

sampling for contaminants of concern would be conducted both on site and in appropriate reference area(s).

The decision process on the use of reference areas for sampling contaminants in tissues is shown in

Figure 6-4. Statistical tests will be used in the measurement of the contaminant-specific biological response

in samples from OU No. 1 and the reference areas. Use of statistical tests will be consistent with DQOs and

quality assurance provisions of the QAPiP.

Additional ecotoxicological studies or toxicity tests may include in-situ (in-field) and/or laboratory toxicity tests.

In-situ methods usually involve exposing animals in the field to existing aquatic or soil conditions. Laboratory

toxicity tests can be used to evaluate the lethal or sublethal effects of chemicals as they occur in environmental

media. Both approaches can be used to test for toxicity of mixtures as they actually occur in the environment.

Selection of a particular methodology is generally based on the capability of the method to demonstrate a

measurable biological response to the selected contaminant(s) of concern in addition to those specific criteria

presented in Subsection 6.2.9.

6.2.11 Task 10: Environmental Evaluation Report

Task 10 will include the summary of information and production of an Environmental Evaluation Report as part

of the RFI/FI Report. The Environmental Evaluation Report will be prepared in a clear and concise manner

to present study results and interpretation. Relevant data from the environmental evaluation, in addition to

relevant Phase II RFI/RI data, will be integrated and evaluated in the characterization of potential environmental

impacts. The following topics will be covered in the report:

Objectives

Scope of Investigation

Site Description

- Contaminants of Concern and Key Receptor Species
- Contaminant Sources and Releases
- Exposure Characterization
- Contamination (Impact) Characterization
- Remediation Criteria
- Conclusions and Limitations

A proposed, detailed outline of the report is shown in Table 6-11.

Remediation Criteria

The primary element used in the assessment of environmental effects or risk is a set of environmental criteria to which measured and or predicted concentrations of hazardous constituents in abiotic media are compared. Where these criteria are exceeded, adverse effects are likely to occur. Where water quality or other available federal or state criteria are available for comparison to concentrations of contaminants, they are generally used (see Section 6.2.7) (EPA, 1989a). Remediation criteria can also be developed from other environmental statutes, such as the Toxic Substances Control Act or the Federal Insecticide, Fungicide and Rodenticide Act, or through the conduct of an environmental risk assessment such as outlined in this work plan.

Remediation criteria protective of biota are not available for contaminants in soils, or for many of the contaminants that occur in aquatic ecosystems at hazardous waste sites. Remediation criteria protective of site-specific plants and animals for the contaminants of concern can be developed in this environmental evaluation based on ecological effects criteria and detailed food-web analyses using a calibrated/validated pathways model. Ecological effects criteria are determined by tracing the biomagnification of contaminant residues from organisms at the top of the food web back through intermediate trophic levels to the abiotic environment. The "no effects" criteria levels for abiotic media are then derived from contaminant concentrations known to produce sublethal effects in the most sensitive (usually highest trophic level) organisms. Development of ecological effects criteria for OU No. 2 will be based on results of the pathways model as well as available data which document potential adverse effects from contaminants of concern on key biological receptors. The process for establishing ecological criteria is shown in Figure 6-5. Determination of these criteria for OU No. 2 will be coordinated with other RFI/RI studies and environmental evaluations.

TABLE 6-11

PROPOSED ENVIRONMENTAL EVALUATION REPORT OUTLINE FOR 903 PAD. MOUND, AND EAST TRENCHES AREAS

EXECUTIVE SUMMARY

1.	^	INTR	ICT	
1.		100 100	 	L JIN

- 1.1 OBJECTIVES
- 1.2 SITE HISTORY
- 1.3 SCOPE OF EVALUATION

2.0 SITE DESCRIPTION

2.1 PHYSICAL ENVIRONMENT

- 2.1.1 Air Quality/Meteorology
- 2.1.2 Soils
- 2.1.3 Surface Water
- 2.1.4 Groundwater

2.2 BIOTIC COMMUNITY

- 2.2.1 Freshwater Community
- 2.2.2 Terrestrial Community
- 2.2.3 Protected/Important Species and Habitats

3.0 CONTAMINANT SOURCES AND RELEASES

- 3.1 SOURCES
- 3.2 RELEASES

4.0 CONTAMINANTS OF CONCERN

- 4.1 CRITERIA DEVELOPMENT FOR SELECTION OF CONTAMINANTS OF CONCERN
- 4.2 DEFINITION OF CONTAMINANTS

5.0 TOXICITY ASSESSMENT

- 5.1 TOXICITY ASSESSMENTS OF CONTAMINANTS OF CONCERN
- 5.2 CONTAMINANT EFFECTS
 - 5.2.1 Terrestrial Ecosystems
 - 5.2.2 Aquatic Ecosystems

6.0 EXPOSURE ASSESSMENT

- 6.1 CONTAMINANT PATHWAYS AND ACCEPTABLE CRITERIA DEVELOPMENT
 - 6.1.1 General Methodology for Pathway Analysis
 - 6.1.2 Selection of Key Receptor Species

Sheet 1 of 2

TABLE 6-11 (Continued)

PROPOSED ENVIRONMENTAL EVALUATION REPORT OUTLINE FOR 903 PAD, MOUND, AND EAST TRENCHES AREAS

6.2	EYPOS! IRE	POINT	IDENTIFICATION
D.Z		PUINT	IDENTIFICATION

- 6.2.1 Soil
- 6.2.2 Water
- 6.2.3 Vegetation

6.3 CHEMICAL FATE AND TRANSPORT

6.4 EXPOSURE POINT CONCENTRATIONS

- 6.4.1 Soil and Sediment Concentrations
- 6.4.2 Surface Water Concentrations
- 6.4.3 Groundwater Concentrations
- 6.4.4 Vegetation Concentrations

6.5 EXPOSURE PATHWAYS

- 6.5.1 Terrestrial Pathway
- 6.5.2 Freshwater Pathway

7.0 CONTAMINATION CHARACTERIZATION

7.1 DEVELOPMENT OF ECOLOGICAL EFFECTS CRITERIA

- 7.1.1 Air Criteria
- 7.1.2 Soil and Sediment Criteria
- 7.1.3 Freshwater Criteria
- 7.1.4 Vegetation Criteria

7.2 EFFECTS CHARACTERIZATION

7.2.1 Terrestrial Pathway

- 7.2.1.1 Air
- 7.2.1.2 Soil
- 7.2.1.3 Vegetation

7.2.2 Freshwater Pathway

- 7.2.2.1 Air
- 7.2.2.2 Surface Runoff
- 7.2.2.3 Seeps and Springs

8.0 ASSUMPTIONS AND UNCERTAINTIES

9.0 RECOMMENDATIONS AND CONCLUSIONS

10.0 REFERENCES

Sheet 2 of 2

The acceptable (no-effects) criteria levels will be used in conjunction with ARARs to evaluate potential adverse effects on biota as appropriate for the environmental evaluation portion of the Phase II RFI/RI. This approach will be integrated with the Human Health Risk Assessment process and will assist in the development of potential remediation criteria.

6.3 FIELD SAMPLING PLAN

The OU No. 2 Environmental Evaluation is planned in 10 tasks as described in Subsection 6.2. Field sampling activities will be conducted in Task 3 and Task 9 of the Environmental Evaluation. Task 3 will include brief field surveys, an ecological inventory of biota present at OU No. 2, and initial aquatic toxicity testing. The field surveys and inventory will be conducted to obtain information on the occurrence, distribution, and general abundance of biota in OU No. 2. Data obtained in the field inventory will be used to identify key receptor species, to develop a site-specific foodweb model, and to provide input to the pathways analysis and contamination assessment. Planning for the Task 9 tissue analysis program will begin in Task 2 so that samples collected in the Task 3 field inventory may be used wherever possible (i.e., where contaminants of concern have been defined and field sampling protocol have been developed). Final determination of the need for further ecotoxicological studies in Task 9 will be made in Task 8, Planning, after completion of the contamination assessment.

The following FSP is provisional and will be periodically revised as appropriate. The Task 3 sampling plan is largely complete but may be altered in order to better coordinate with the surface water and soil sampling programs for OU No. 2 or other operable units. The Task 9 field sampling plan will be designed in greater detail after contaminants of concern and key receptor species have been identified and a preliminary determination of food webs and contaminant source-receptor pathways has been developed. This information will allow determination as to which contaminants of concern are likely to be present in sufficient concentrations to be detected in biota and which biota are most practical and suitable for sampling.

SOPs for sampling biota as part of the Environmental Evaluation process at Rocky Flats are currently in publication. The SOPs will include discussion of purpose and scope, responsibilities and qualifications, references, equipment, and execution of protocols. Sampling procedures for the following organisms will be included in the forthcoming document:

- Periphyton
- Benthic macroinvertebrates
- Plankton
- Fishes
- Large mammals

- Small-mammals
- Birds
- Reptiles and amphibians
- Terrestrial arthropods
- Terrestrial vegetation
- Soil microbes

SOPs that are currently being developed in addition to the above include the following:

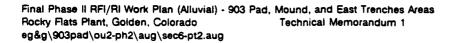
- Design of FSPs
- Selection of Reference Areas
- Recording and Managing Data
- Preserving and Handling Samples
- Conducting Laboratory Studies
- Incorporating QA/QC

The preceding SOPS are referenced in the following OU No. 2 FSP where appropriate.

6.3.1 Sampling Objectives

The Task 3 Ecological Field Investigation for OU No. 2 has four broad objectives:

- Conduct brief field surveys and an ecological inventory to describe the existing ecological setting in terms of habitats, vegetation, wildlife, and aquatic species. Conduct initial aquatic toxicity testing using *Ceriodaphnia spp.* and fathead minnows. Observe OU No. 2 for obvious signs or zones of contamination or injury to biota and their habitats will be made. Accomplish ecological field inventory, through the use of established ecological field methodologies (e.g., Mueller-Dombois and Ellenberg, 1974; Southwood, 1978; Krebs, 1989).
- 2. From the above data, identify key food web species which represent the major flow of energy and nutrients and thus the major pathways for contaminant transfer from physical environmental media to higher trophic-level ecological receptors.
- 3. Identify the presence or absence of protected or other important species and habitats.
- 4. Provide site-specific information for determining objectives, measurement endpoints and methodologies for Task 9 field/laboratory contamination studies.



Data from the field survey, inventory, and aquatic toxicity tests will be summarized, tabulated and accompanied with a narrative description of the following data types:

- Species Present (Diversity)
- Habitat Descriptions/Mapping Units (Clark et al., 1980)
- Soil Descriptions/Classifications (part of RFI effort)
- Critical/Protected Habitats
- Protected Species
- Terrestrial and Aquatic Food Webs
- Potential Exposure Pathways
- Abundance of Key Species
- Vegetation Cover
- Vegetation Frequency and Density (shrubs/trees)
- Vegetation Importance (community dominance) Values
- Aquatic Toxicity Test Results

Appropriate statistical tests will be used to analyze the data so that precision and accuracy of the results can be presented at a stated level of confidence. Depending on the data types being analyzed, within-and-between station differences, within-and-between season differences, and within-and-between species differences will be presented. Means, variances, standard errors, analyses of variance, regression, and correlation coefficients will be computed as appropriate. Where sample sizes are insufficient to detect differences, only descriptive statistics will be prepared.

6.3.2 Sample Location and Frequency

Both Task 3 and Task 9 field sampling activities for OU No. 2 will be located and timed to the extent possible to coincide with collection of other media sampling (soils, surface water, and ground water) as well as sampling activities at other operable units. This integrated sampling approach is consistent with EPA guidance and will provide a synoptic view of potential contaminants in all relevant media at one time. The field sampling plan for Task 3 is based on the assumption that brief field surveys will be conducted in the spring, summer, fall, and winter and that the ecological field sampling program will take place within the May-June and July-August timeframes. Aquatic toxicity testing will take place in May-June (high flow) and September-October (low flow). Information from the initial surveys and field inventory may be used to modify sampling parameters for later field investigations.

Sampling locations are largely located at or downgradient from areas of known or suspected contamination. Sampling locations were selected to coincide with sampling efforts in abiotic media and to characterize the biotic communities that are present. The intent of the selected locations was not to test specific hypotheses regarding the effects of contamination, but to characterize the ecological communities that are present and provide site-specific input to the pathways model.

6.3.2.1 Locations for Vegetative Sampling

Vegetation sampling for phytosociological data will be performed at OU No. 2, and along South Walnut Creek, the SID and Woman Creek, north and south of the 903 Pad, Mound, and East Trenches Areas. A systematic walk-through of these areas will be conducted in the spring, summer, and fall to observe species composition.

A stratified randomization procedure will be utilized to identify sampling locations for the quantitative vegetative description portion of the field inventory. The basis for selecting a random procedure of vegetation transect/plot location is to obtain as unbiased an estimator as possible of true population parameters for herbaceous cover and shrub/tree density and frequency. Stratification is required because several distinct vegetation types appear to be present in the study area, including prairie grassland, marsh, streambank vegetation, well-vegetated disturbed areas, and sparsely vegetated disturbed areas.

The basis for stratification will be a vegetation type map, to be prepared based on the 1975 University of Colorado vegetation map of Rocky Flats and the Clark et al. (1980) report, updated by visual observations during the field surveys. This map will address the 903 Pad, Mound, and East Trenches Areas.

Transects for the quantitative community surveys will be located near soil sampling sites (see Subsection 5.1.1 in RFI/RI Work Plan (EG&G, 1991d) wherever possible. From each soil sampling point, the centerpoint of a vegetation transect will be selected based on a random distance (to 10 meters) and random direction, using random numbers tables. Transect locations will be selected until an adequate number has been selected for each major vegetation type at each IHSS. Locations will be discarded under several conditions: where the selected location is in a vegetation type for which an adequate number of transects has already been selected (for each IHSS); where the vegetation is not homogeneous (i.e., located in more than one type or across an ecotone); and where the transect would be located in buildings or paved areas. A similar process will be used for transects along South Walnut Creek, Woman Creek and the SID, where the sample locations will be located in the general area of the surface-water/sediment sampling points. Since vegetation types associated with these features tend to be linear, the randomization process may require limits on direction. Multiple transects will be located near (within 50 meters of) each surface water/sediment sampling point to provide an adequate sample size.



6.3.2.2 Locations for Periphyton, Macrobenthos and Fish Sampling

Periphyton, macrobenthos, and fish samples will be collected at the following surface water sampling locations:

SW-28, SW-32, SW-54, SW-70, and Ponds B-4, B-5, C-1, and C-2 (Figure 6-6). Should the organisms or proper

habitat be absent at a particular location, then the nearest location downstream with suitable habitat will be

sampled and located on a map. Sampling at OU No. 2 will be coordinated with OU No. 2 surface water and

sediment sampling activities as well with OU No. 5 and OU No. 1 sampling programs. Both sediment and

surface water quality data will be collected at the same locations and time as the aquatic biota sampling.

Sampling locations may be altered to ensure these efforts are coordinated. Sampling locations for aquatic

biota may also be altered depending on DQOs or required sample size.

6.3.2.3 Locations for Wildlife Sampling

A terrestrial wildlife inventory will be conducted within the 903 Pad, Mound, and East Trenches Areas, and

along South Walnut Creek, the South Interceptor Ditch, and Woman Creek north and south of 903 Pad, Mound,

and East Trenches Areas. Small mammal sampling will be conducted, to the extent possible, at the vegetative

sampling locations. Searches for reptiles will be conducted in appropriate habitats in OU No. 2.

6.3.2.4 Locations for Initial Toxicity Testing

Locations for initial aquatic toxicity testing will be mostly the same as those for periphyton, macrobenthos, and

fish sampling: SW-28, SW-32, SW-54, SW-70, and Ponds B-4, B-5, C-1, and C-2 (Figure 6-6). Toxicity testing

activities for OU No. 2 will be coordinated with toxicity testing activities proposed for OU No. 1 and OU No.

5 as part of the implementation of the field sampling effort.

6.3.2.5 Tissue Sampling Locations

Locations for the collection of tissue samples (terrestrial vegetation, periphyton, benthos, macrobenthos, fish)

will be the same as those for terrestrial and aquatic sampling. An initial identification of species for tissue

sampling will be made in Task 2. Additional sampling requirements will be determined during the

contamination assessment (Tasks 4 through 7) and contaminant data from surface water, soil and sediment

sampling. The intent is to collect tissue samples where existing abiotic media sampling has indicated

significant contamination to occur. Development of the OU No. 2 tissue sampling program will be coordinated

with OU No. 5 and OU No. 1 programs.

6.3.2.6 Sample Frequency

Brief field surveys will be conducted during 1-week periods in the spring, summer, fall, and winter. Special note

of transitory species, migratory species, and seasonal breeding habits will be made during these multi-season

surveys.

Field inventory sampling will occur during the May-June and July-August timeframes. Samples collected during

the inventory will be saved and used in the tissue analysis studies where sampling and analysis protocol have

been established.

Initial toxicity tests will also be conducted during May-June (high flow) and September-October (low flow). Two

acute and two chronic tests will be conducted within 1 to 2 weeks of each other during each season. If toxicity

is observed in either acute or chronic tests at any one station, then a supplemental program will be designed

for that location to determine if the toxicity is consistent and to determine the potential extent of the toxicant.

6.3.3 Reference Areas

Tissue analysis studies may require the sampling of contaminated and control areas in order to establish a

relationship between contaminated conditions and background conditions in areas not exposed to Rocky Flats

Plant contamination. Selection of reference areas may be based on criteria developed in the Task 1 preliminary

planning process and may be coordinated with similar efforts at other operable units. Potential selection

criteria include species to be sampled or similarity to OU No. 2 in terms of topography, aspect, soils,

vegetation, range type, and land use history. Reference areas should be upwind from prevailing air flow

patterns through Rocky Flats Plant and upstream from drainage off Rocky Flats Plant.

SOPs for sampling biota as part of the environmental evaluation process at Rocky Flats are currently in

publication. Additional aquatic reference areas ideally should be located in Rock Creek. A site visit will be

made of the proposed aquatic sampling locations for OU No. 2, OU No. 1, and OU No. 5. Habitat

characteristics will be noted if not previously recorded in ongoing Rocky Flats Plant studies (depth, flow,

substrate type, pool/riffle, aquatic/streamside vegetation, etc.). This process will be repeated at potential

reference sites.

Reference areas would be selected only after criteria, data quality objectives, and measurement endpoints are

identified. The process for selecting reference areas will be initiated in Task 1.

6.3.4 Field Survey and Inventory Sampling Methods

Sampling methods for periphyton, benthic macroinvertebrates, fishes, mammals, birds, reptiles, and amphibians, terrestrial arthropods, and terrestrial vegetation are detailed in the Ecology SOPs. The SOPs include several standardized forms to be used when sampling biota. Site Description Form 5.0D will be used for sampling terrestrial biota; stream and pond habitat description forms (Forms 5.0A and 5.0B) will be completed at each of the aquatic sampling locations. Chain-of-custody field sample forms will be completed where samples are collected for laboratory analysis or voucher specimens. Additional forms to be completed are specified in the following subsections.

6.3.4.1 Vegetation

Both qualitative and quantitative methods will be used to characterize the terrestrial and wetland vegetation at OU No. 2. Qualitative surveys using a relevé analysis (see Ecology SOPs) will be conducted in the spring, summer, and fall to record the floristic composition of the plant communities present. These qualitative surveys will include a systematic walk-through of the 903 Pad, Mound, and the East Trenches Areas, the SID, South Walnut Creek, and the Woman Creek areas. The following data will be recorded on all vegetation species encountered:

- Scientific name
- Common name
- Life form
- Vegetative stage at the time
- Qualitative statement on condition
- Qualitative statement on abundance (relevé analysis see Ecology SOPs)

Quantitative procedures will be used to collect structural and compositional data. Point-intercept transects will be used to collect data on species cover. Data will be recorded on Form 5.10B, Point-Intercept Data Form. Belt transects will be used in conjunction with the point-intercept transects to collect data on shrub cover and density. Trunk diameter, height, canopy diameter, and species will be recorded for any trees within the belt transect or within any IHSS. Shrub and tree data will be recorded on Form 5.10C, Belt Transect Data Form. Production data (standing biomass) will be collected from 1/4- to 1-m² quadrants at the same locations as the transects. Different quadrant sizes may be used depending on vegetation type (e.g., a 1/4-m² quadrant may be used on dense streambank vegetation). Production data will be recorded on Form 5.10D.

Each plot or 10-meter transect will be considered as an observation in calculating the mean and variance. Sample adequacy will be determined for total herbaceous cover and total fresh weight biomass using Cochran's formula (1977):

$$N = \frac{(t^2)(s^2)}{[(x)(d)]^2}$$

where:

N = the minimum number of samples needed

t = t distribution value for a given level of confidence

 s^2 = the variance estimate

x = the mean of the sample

d = the level of accuracy desired

6.3.4.2 Terrestrial Wildlife and Invertebrates

The Task 3 survey is planned to note the presence or absence of terrestrial/wetland species and to make note of their food habits. The survey procedure will include a systematic walk-through of the 903 Pad, Mound, and East Trenches Areas, SID, South Walnut Creek, and Woman Creek to record ecological features. Field data will be recorded on the standardized Qualitative Survey/Relative Abundance Data Form 5.0C for large mammals, small mammals, birds, reptiles and amphibians, and terrestrial arthropods. Opportunistic observations of bird and raptor nests, large mammal pellets, and mammal burrow/dens will be recorded on the appropriate forms. Vocalization surveys for birds and anurans will also use the appropriate forms. Data to be recorded include:

- Species encountered/ observed
- Scientific name
- Common name
- Qualitative statement on:
 - Condition
 - Abundance
 - Habitat requirements
 - Predator/prey species/food habits
 - Regulatory status (to be determined prior to field sampling)
- Species presence will be determined by:
 - Visual observation
 - Vocalization
 - Burrow/den
 - Nest
 - Droppings/scat

Quantitative information on wildlife populations will be obtained in the Task 3 field inventory. Inventory sampling will include the following procedures, which are detailed in the SOPs:

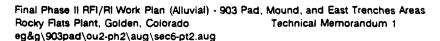
- Live trapping of small mammals on 903 Pad, Mound, and East Trenches Areas, and along the SID, South Walnut Creek, and Woman Creek. Data to be recorded include:
 - Scientific name/common name
 - Sex
 - Reproductive condition
 - Weight
 - Life history stage
- Reptile occurrence will be recorded along the same transects used for small mammal trapping in addition to habitat searches. Data to be recorded include:
 - Species encountered
 - Activity
 - Habitat
 - Qualitative statement on abundance
- Medium- and larger-sized mammals will be counted by recording all species along a systematic walk-through of the 903 Pad, Mound, and East Trenches Areas, the SID, South Walnut Creek, and Woman Creek. The counting will occur during the small mammal transect trapping. Species encountered and activity will be recorded.
- Foliage invertebrates will be collected by sweep net and beating. Where conditions permit, foliage invertebrate and arthropod sampling may be conducted using a D-vac suction sampler in place of sweep netting (see Ecology SOPs). Data to be recorded will include:
 - Host plant
 - Herbivore
 - Position in food web

6.3.4.3 Periphyton

Sampling to characterize periphyton communities will occur at the selected locations along Woman Creek, South Walnut Creek, the SID, and Ponds B-4, B-5, C-1, and C-2 (see SOP). Triplicate samples will be taken on a transect upstream and within 10 meters of the designated sampling location. Data to be collected include:

- Scientific name
- Algal density (cell counts of each taxon)
- Biomass (chlorophyll-a and phaeophytin-a concentrations)

Field data will be recorded on the Periphyton Field Sample Form 5.1A (see SOP 5-1). Data from quantitative sampling will be used to determine species diversity and standing crop (biomass). All analyses will be completed within 5 days of the collection of the slides from the field (EPA, 1987c).



6.3.4.4 Macrobenthos

Benthic invertebrates are the most common fauna used in ecological assessments of contaminant releases and

are defined as the invertebrates retained by screens of mesh size greater than 0.2 mm. Macrobenthos will be

sampled at the aquatic sampling locations shown in Figure 6-6 using the procedures described in the SOPs.

Triplicate samples will be taken on a transect upstream and within 10 meters of the designated sampling

locations. Data to be collected include:

Scientific name (generally to genus)

Number of individuals in each taxon

Field data will be recorded on the benthic macroinvertebrate field sample form 5.2A. Data from quantitative

samples will be used to determine macroinvertebrate density (standing crop), taxa richness, and taxa diversity.

6.3.4.5 Fish

Fish will be collected in 10- to 25-meter-long collection areas using a backpack shocker or by seining blocked-

off creek sections. In Ponds B-4, B-5, C-1 and C-2, fish will be sampled from a flat-bottom boat using an

electroshocker. Data to be collected include:

Scientific name

Number of individuals in each taxon

Length

Weight

Scales will be collected to obtain data on age classes versus size, population structure, and survivorship. Field

data will be recorded on the Fish Field Inventory form 5.4B (see SOP 5-4). Samples will be taken for laboratory

identification/confirmation. Analyses will consist of compiling and summarizing the number, size, and weight

of each species of fish captured at each sampling site. Graphic presentations may include fish length-

frequency histograms and plots of catch-per-effort for each sampling area.

6.3.5 Initial Toxicity Tests

The initial toxicity testing program will be limited to aquatic organisms and will include standardized EPA acute

and chronic tests with fathead minnows and Ceriodaphnia spp. Water samples will be cooled to 4°C and

shipped to the laboratory conducting the toxicity tests within 12 to 24 hours. The toxicity tests will be initiated

within 36 hours of the field collection time. The duration of the static renewal acute tests will be 48 hours for

Ceriodaphnia spp. and 96 hours for fathead minnows. The test water will be renewed daily using dilution water

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from the sampling station. The static renewal chronic tests will last for 7 days for fathead minnows and until

60 percent of the Ceriodaphnia spp. in the control vessels have three broads. Quality control procedures will

conform to the EPA requirements for NPDES toxicity testing currently being used at Rocky Flats and to the

QAPIP.

6.3.6 Tissue Analysis Sampling Methods

The methodologies selected for tissue analysis studies will depend on the contaminants of concern and their

anticipated effects on the selected key receptor species. Contaminants of concern and key receptor species

will be determined as early as possible in Task 2. It is anticipated that some biota samples collected in the

Task 3 field inventory can be used for tissue analysis. Standardized site protocol for preserving samples for

tissue analyses will be followed in those instances where it is anticipated that tissue analyses will be conducted.

Analyses for metals and radionuclides in biota may call for a greater biomass of tissue than is available through

standard collection methods. At least 80 grams of material (wet weight) is needed per sample for metals

analysis, and 100 grams of material (dried and ashed) is needed for radionuclides. Obtaining this amount of

sample may be impractical for some species of vegetation, periphyton, and macrobenthos. It is also not the

intent of the sampling program to cause unnecessary disturbance or damage to the biota communities in order

to collect sufficient samples. Sampling design will be adequate to ensure statistically valid results. DQOs for

the tissue sampling program will be evaluated with respect to this determination prior to field collection

activities.

Based on the literature reviewed and the information presented in this report, it is anticipated that most tissue

samples will be analyzed for metals and very few samples, if any, may be analyzed for radionuclides. Tissue

samples collected for contaminant analysis will be sent to a laboratory for specific metals and radionuclide

analyses as determined in the preliminary Task 1/Task 2 environmental evaluation. Analytical methods will

follow SOPs.

Holding times, preservation methods, sample containers, and field and laboratory quality control sample

numbers are contained in the QAPiP and shown in Table 6-12. Tissue sampling protocol for biota are not

necessarily standardized and may vary depending upon the laboratory conducting the analyses. Specific

sample preparation requirements will be reported in SOPs which are currently in development.

6.3.7 Sampling Equipment

Equipment for field sampling of biota are identified in the Volume V Ecology SOPs.

6.4 SCHEDULE

The following Figure 6-7 presents a proposed schedule for implementation of the OU No. 2 environmental evaluation. The schedule follows the task approach presented in this environmental evaluation. While many of the tasks are sequential, most tasks will overlap in time. The months indicated in the table reflect the timeframe in which the activity will occur and not necessarily the amount of time necessary to complete the task. The schedule is provisional and likely to change depending on the Phase II OU No. 2 RFI/RI activity schedule as well as schedules from other operable units.

TABLE 6-12 HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES

	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size ⁺⁺
SAMPLES FOR METALS ANALYSES				•
Terrestrial Vegetation				
- Metals Determined by ICP**	6 mos	Freeze & ship w/ dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Metals Determined by GFAA+	6 mos.	Freeze & ship w/ dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/ dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Mercury	28 days	Freeze & ship w/ dry ice	Paper bag inserted into plastic bag and sealed	5 g
Periphyton, Benthic Macroinvertebrates, Fish				
- Metals Determined by ICP	6 mos.	Freeze & ship w/ dry ice	Plastic	25 g
- Metals Determined by GFAA	6 mos	Freeze & ship w/ dry ice	Plastic	25 g
- Hexavalent Chromium	24 hours	Freeze & ship w/ dry ice	Plastic	25 g
- Mercury	28 days	Freeze & ship w/ dry ice	Plastic	5 g

HOLDING TIMES, PRESERVATION METHODS, AND SAMPLE CONTAINERS FOR BIOTA SAMPLES TABLE 6-12 (Continued)

	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size
SAMPLES FOR RADIONUCLIDE ANALYSES	•			
Terrestrial Vegetation				
 Uranium-233, -234, -235, -238 Americlum-241 Plutonium-239/240 	g mos	Freeze & ship w/ dry ice	Paper bag inserted into plastic bag and sealed	100 g
Periphyton, Benthic Macroinvertebrates, Fish				
- Uranium-233, -234, -245, -238 Americium-241 Plutonium-239/240	6 mos	Freeze & ship w/ dry ice	Plastic	100 g

Inductively Coupled Argon Plasma Emission Spectroscopy. Metals to be determined include Ba, Cr, Cu, and Fe. **ICP

Graphite Furnace Atomic Absorption Spectroscopy. Metals to be determined include As, Cd, Ll, Pg, Se, and Sr. +GFAA =

Sample size may vary with specific laboratory requirements.

This section provides a preliminary identification of chemical-specific ARARs for alluvial (upper HSU) ground water and soils at OU No. 2 so that appropriate analytical detection limits are used during the RFI/RI. Use of appropriate detection limits is necessary to allow evaluation of compliance with ARARs in the CMS/FS report. As described in Section 7.2, evaluation and establishment of location-specific ARARs are a part of the RI process and will be addressed in the RFI/RI Report. Final chemical-specific ARAR determinations will also be addressed in the RFI/RI Report. Identification of action-specific ARARs and remediation goals is a part of the feasibility study process and will be addressed in the CMS/FS Report.

7.1 THE ARAR BASIS

The basis for ARARs is cited in Section 121(d) of CERCLA, as amended by the SARA, which requires that Fund-financed, enforcement, and federal facility remedial actions comply with all applicable or relevant and appropriate federal environmental or promulgated state environmental or facility siting laws. For the purposes of identification and notification of promulgated state standards, the term "promulgated" means that the standards are of general applicability and are legally enforceable [NCP, 40 Code of Federal Regulations (CFR) 300.400(g)(4)].

Health-based, chemical-specific ARARs pertinent to ground water and soils (environmental media addressed by this work plan) have been identified for the EPA CLP, TCL organic, and TAL inorganic compounds, as well as radionuclides and conventional pollutants, that were detected above background. The chemical-specific ARARs are primarily derived from federal and state health and environmental statutes and regulations. As discussed below, in some instances these standards are classified as items "to be considered" (TBC). A summary of potential chemical-specific ARARs for the contaminants found at the 903 Pad, Mound, and East Trenches Areas in alluvial ground water is presented in Table 7-1. Maximum contaminant concentrations identified in the respective media at OU No. 2 are shown in the table for comparison to the ARAR or TBC. These ARARs pertain to both the upper and unconfined lower HSUs (alluvial and unconfined bedrock ground water), due to the potential hydraulic interconnection of the two unconfined units. The same list of parameters will be utilized for analysis of samples collected from ground water in both the alluvial and bedrock OU No. 2 RFI/RI work plans. In the final chemical-specific ARAR analysis, a common list of parameters will be analyzed for both HSUs.

One medium for which chemical-specific ARARs do not currently exist is soils. As the remedial investigation proceeds, information will become available from the baseline risk assessment that will allow a determination

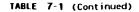
TABLE 7-1

POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES

Max im.m Concentrations Well In OU 2 Area Alluvial Designation Detection Proposed Proposed Ground Water* # & Sample Limit ARAR TBC Chemical Date $(\mu g/\ell)$ $(\mu g/\ell)$ $(\mu g/t)$ Reference Comment $(\mu g/\ell)$ Organic Compounds 1587 Acetone 1300B 10 10U Parameter is RCRA (40 (10/07/87)CFR Part 264) Appendix 1X constituent. RCRA 40 CFR Part 264 Subpart F (background) is TBC. Methylene Chloride 240JB 1587 5 SU Parameter is RCRA (40 (10/07/87)CFR Part 261) Appendix VIII constituent. RCRA 40 CFR Part 264 Subpart f (background) is TBC. 528000 Tetrachloroethene 0174 5 10 WQCC Ground-Water (05/22/87)(5) Standard; State-Wide Interim Organic Pollutant Standard. (SDWA MCL, in parenthesis, [40 CFR 141.61(a)) is also TBC**.) 53 3687BR Toluene 5 2420 WQCC Ground Water Maximum detected (11/05/87)(1000) Standard; State-Wide concentration is below Interim Organic potential IBC standard. Pollutant Standard. SDWA MCL, in parentheses, [40 CFR 141.61(a)] is also TBC**. **Trichloroethene** 221860 3687BR 5 5 SDWA MCL [40 CFR 141.61 (05/04/88)(a)]. Carbon Disulfide 4JA 0174 5 Sυ Parameter is RCRA (40 Maximum detected (01/03/89)CFR Part 261) Appendix concentration is below VIII constituent. RCRA potential TBC standard. 40 CFR Part 264 Subpart f (background) is TBC. Chloroform 5427 3687BR 5 100 SDWA MCL (40 CFR Standard is for total (11/05/87)141.12). trihalomethanes.

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POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES

Chemical	Maximum Concentrations In OU 2 Area Alluvial Ground Water* (µg/l)	Well Designation # & Sample Date	Detection Limit (µg/f)	Proposed ARAR (µg/ℓ)	Proposed TBC (µg/l)	Reference	Comment
Vinyl Chloride	930	3586 (01/03/89)	10	· 10U		SDWA MCL [40 CFR 141.61 (a)].	Standard (2 µg/l) is below detection limit. ARAR defaults to detection limit.
Organic Compounds (cont.)		·					
Carbon Tetrachloride	4835	4286 (09/03/87)	5	5		SDWA MCL [40 CFR 141.61 (a)].	
1,1-Dichloroethane	62A	3586 (01/03/89)	5		5 U	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart F (background) is TBC.	
1,2-Dichloroethane	400	0171 (05/21/87)	5	5		SDWA MCL (40 CFR 141.61(a)].	
1,1-Dichloroethene	1044	3687BR (11/05/87)	5	7		SDWA MCL (40 CFR 141.61 (a)].	
1,2-Dichloroethene (total)	1600	3586 (03/17/87)	5		70	WQCC Ground-Water Standard; State-Wide Interim Organic Pollutant Standard is IBC.	
1,1,1- Trichloroethane	2892	0171 (07/02/87)	5	200		SDWA MCL (40 CFR 141.61(a)).	
1,1,2- Irichloroethane	51	0271 (02/25/88)	5		28	WQCC Ground-water Standard; State-Wide Interim Organic Pollutant Standard is IBC.	
4-Methyl-2-pentanone	35	3287 (03/09/88)	10		100	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart f (background) is IBC.	

POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND MATER AT THE 903 PAD, MOUND, AND EAST TRENCHES

Chemical	Maximum Concentrations In OU 2 Area Alluvial Ground Water* (µg/t)	Well Designation # & Sample Date	Detection Limit (µg/t)	Proposed ARAR (µg/ℓ)	Proposed TBC (µg/f)	Reference	Comment
2 · Hexanone	975	3687BR (03/09/88)	10		100	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart F (background) is TBC.	
Organic Compounds (cont.)							
Styrene	94	0174 (01/03/89)	5		5U (100)	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart F (background) is IBC. SDWA MCL, in parenthesis, [40 CFR 141.61(a)] is IBC**.	
Xylene (total)	4.1	3986 (03/09/88)	5		5U (10,000)	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart F (background) is TBC. SDWA MCL, in parentheses, [40 CFR 141.61(a)] is TBC**.	Maximum detected concentration is below potential TBC standard.
Ethyl Benzene		3986 (03/09/88)	5		680	WQCC Ground-Water Standard; State-Wide Interim Organic Pollutant Standard is TBC.	Maximum detected concentration is below potential ARAR standard.
Benzene	2JA	0271 (10/31/88)	5	5		SDWA MCL [40 CFR 141.61(a)].	Maximum detected concentration is below potential ARAR standard.

POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES

Chemical	Maximum Concentrations In OU 2 Area Alluvial Ground Water* (mg/t)	Well Designation # & Sample Date	Detection Limit (mg/f)	Proposed ARAR (mg/f)	Proposed TBC (mg/ t)	Reference	Comment
Dissolved Metals	·						j
Aluminum	2.6796	2587BR (10/21/87)	0.20		5.0	WQCC Site-Specific Ground-Water Standard; Table 3, Agricultural Standard is TBC.	Maximum detected concentration is below potential TBC standard.
Antimony	0.1177	2987 (08/08/88)	0.06		0.060	Parameter is RCRA (40 CFR Part 261) Appendix VIII Constituent. RCRA 40 CFR Part 264 Subpart F (background) is TBC.	Maximum detected concentration is below potential TBC standard.
Arsenic	0.0041	3586 (03/02/88)	0.01	0.05		SDWA MCL [40 CFR 141.11 (b)].	Maximum detected concentration is below potential ARAR standard.
Barium	0.9321	1487BR (08/31/87)	0.20	1.0		SDWA MCL [40 CFR 141.11(b)]. (SDWA MCL [40 CFR 141.62(b)\ is TBC**.)	Maximum detected concentration is below potential ARAR standard.
8eryllium .	0.004J	4186 (10/22/87)	0.005		0.005U	Parameter is RCRA (40 CFR Part 261) Appendix VIII Constituent. RCRA 40 CFR Part 264 Subpart F (background) is TBC.	Maximum detected concentration is below potential TBC standard.
Cadmium	0.009A	6286 (06/10/89)	0.005	0.01	0.005	SDWA MCL (40 CFR 141.11(b)]. SDWA MCL (40 CFR 141.62(b)] is TBC**.	Maximum detected concentration is below potential ARAR standard.
Calcium	408.4416	14878R (08/31/87)	5	NS		No Standard.	
Chromium	0.1223	0374 (10/22/87)	0.01	0.05	0.1	SDWA MCL [40 CFR 141.11(b)]. SDWA MCL [40 CFR 141.62(b)] is 186**.	Analytical results are for total dissolved chromium (Cr ^{*3} and Cr ^{*8})

POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS' AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES

Chemical	Maximum Concentrations In OU 2 Area Alluvial Ground Water* (mg/f)	Well Designation # & Sample Date	Detection Limit (mg/t)	Proposed ARAR (mg/f)	Proposed TBC (mg/f)	Reference	Comment
Dissolved Metals (cont.)							
Copper	0.8355	2987 (08/08/88)	0.025		0.025U (1.3)	Parameter is RCRA (40 CFR Part 264) Appendix IX consitutent. RCRA 40 CFR Part 264 Subpart F (background) is 1BC. SDWA MCLG in parentheses [40 CFR 141.61(a)] is also IBC***.	
lron	4.347	25878R (10/21/87)	0.1		0.3	WQCC Site-Specific Ground-water Standard; Table 2, Secondary Drinking Water Standard is IBC	Analytical results are for soluble iron.
Lead	0.024	6586 (05/28/87)	0.005	0.05		SDWA MCL [40 CFR 141.11(b)].	Maximum detected concentration is below potential ARAR standard. MCL to be deleted.***
Magnes i um	135.7122	2987 (02/29/88)	5	NS		No Standard.	
Manganese	4.3699	3586 (05/03/89)	0.015		0.05	WGCC Site-Specific Ground-Water Standard; Table 2, Secondary Drinking Water Standard is TBC.	Analytical results are for soluble manganese.
Mercury	0.013	4286 (07/23/87)	0.0002	0.002		SDWA MCL (40 CFR 141.11(b)).	
Molybdenum	0.0808	2987 (04/21/88)	0.008	- NS		No Standard.	

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POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND WATER AT THE 903 PAD, MOUND, AND EAST TRENCHES

Chemical	Maximum Concentrations In OU 2 Area Alluvial Ground Water* (mg/f)	Well Designation # & Sample Date	Detection Limit (mg/t)	Proposed ARAR (mg/ l)	Proposed TBC (mg/f)	Reference	Comment
Nickel	1.4097	2987 (04/21/88)	0.04		0.04U	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart F (background) is IBC.	
Dissolved Metals (cont.)				,			
Potassium	31.0	1487BR (08/31/87)	5	NS		No Standard.	
Selenium	0.450	2987 (02/01/89)	0.005	0.01	0.05	SDWA MCL [40 CFR 141.11(b)]. SDWA MCL [40 CFR 141.62(b)] is TBC**.	
Silver	0.128	4286 (05/04/88)	0.01	0.05	0.1	MCL [40 CFR 141.11(b)]. Secondary MCL is TBC**.	MCL to be detected and replaced with secondary MCL.**
Sodium	405.0172	2987 (04/21/88)	5	NS		No Standard.	
Strontium	7.7076	14878R (08/31/87)	0.2	NS		No Standard.	
Thallium ·	0.01*	23878R (09/10/87)	0.01	·	0.01u	Parameter is RCRA (40 CFR Part 2612) Appendix VIII constituent. RCRA 40 CFR Part 264 Subpart F (background) is TBC.	
Vanadium	0.0401*	2587BR (10/21/87)	0.05		0.05u	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart F (background) is IBC.	Maximum detected concentration is below potential TBC standard.
Zinc	2.7735	2987 (08/08/88)	0.02		0.02u	Parameter is RCRA (40 CFR Part 264) Appendix IX constituent. RCRA 40 CFR Part 264 Subpart f (background) is IBC.	

POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND MATER AT THE 903 PAD, NOUND, AND EAST TRENCHES

Chemical	Maximum Concentrations In OU 2 Area Alluvial Ground Water* (mg/f)	Well Designation # & Sample Date	Detection Limit (mg/f)	Proposed ARAR (mg/ f)	Proposed TBC (mg/ t)	Reference	Compent
<u>Mon-Metallic</u> <u>Inorganics</u>							·
pH (min)	7.2	6686 (06/02/89)	0.1		6.5	WGCC Site-Specific Ground-Water Standard; Table 3, Agricultural Standard is TBC.	Minimum pH value is within potential standard.
pH (max)	8.7	6286 (06/10/89)	0,1		8.5	WGCC Site-Specific Ground-Water Standard; Table 3, Agricultural Standard is TBC.	
Nitrite	15.45	3287 (10/26/87)	1.0		1.0	WOCC Site-Specific Ground-Water Standard; Table 1, Human Health Standard is TBC. 1.0 mg/t is also SDWA MCL [40 CFR 141.62(b)]**.	Analytical results are total nitrite plus nitrate as nitrogen. Reanalysis is required to determine if potential nitrite standard is exceeded.
Nitrate	15.45	3287 (10/26/87)	5	10.0		SDWA MCL (40 CFR 141,11 (b))	Analytical results are total nitrite plus nitrate as nitrogen.
Chloride	947	4186 (12/16/87)	5	·	250	WQCC Site-Specific Ground-Water Standard; Table 2, Secondary Drinking Water Standard is TBC.	
Sulfate	1157	2987 (04/21/88)	5		250	WQCC Site-Specific Ground-Water Standard; Table 2, Secondary Drinking Water Standard is IBC.	

POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND MATER AT THE 903 PAD, MOUND, AND EAST TRENCHES

Chemical	Maximum Concentrations In OU 2 Area Altuviat Ground Water (mg/f)	Well Designation # & Sample Date	Detection Limit (mg/f)	Proposed ARAR (mg/f)	Proposed TBC (mg/ t)	Reference	Comment
Non Metallic Inorganics (cont.) TDS	3219	2987 (02/29/88)	5		1643	WQCC Site-Specific Ground-Water Standard; Table 4, Standard is TBC.	Proposed standard is calculated from the upper tolerance interval in background wells. Value includes 95% of the population at 95% confidence, multiplied by 1.25.

POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND MATER AT THE 903 PAD, MOUND, AMD EAST TRENCHES

· Chemical	Maximum Concentrations In OU 2 Area Ground Water* (pCi/t)	Well Designation # & Sample Date	Detection Limit (pCi/t)	Potential ARAR (pCi/f)	Potential TBC (pCi/ &)	Reference	Comment
Dissolved Radionuclides Gross Alpha	250 ±52	0374 (10/22/87)	2	15		SDWA MCL [40 CFR 141.15 (b)]	
Gross Beta	327 ±20	0374 (10/22/87)	4	4 (mrem/yr)		SDWA MCL (40 CFR 141.16 (8))	
Pu ^{239,240}	0.6 ±0.71	6286 (07/06/87)	0.01.		15	WOCC Ground-Water Standard; State-Wide Radionuclide Standard is TBC.	Maximum detected concentration is below potential ARAR standard. Concentration is estimated below minimum detectable limit (MDL).
Am ²⁴¹	0.831 ±0.148	1587 (09/11/87)	0.01		0.05	WOCC Site-Specific Ground-Water Radionuclide Standard is TBC.	
Н _э	560 <u>±</u> 290	4286 (10/14/87)	400	20000		SDWA MCL [40 CFR 141.16 (b))	Maximum detected concentration is below potential ARAR standard.
Sr ee.eo	5.0	0174 (07/23/87)		8		SDWA MCL [40 CFR 141.16 (b)]	Maximum detected concentration is below potential ARAR standard. Concentration is estimated below MDL.
Ulmad	63.7 ±5.3	12878R (02/25/88)	1.8		5	WOCC Site-Specific Ground-Water Radionuclide Standard is TBC.	

POTENTIAL CHEMICAL SPECIFIC ARARS FOR COMPOUNDS AND ELEMENTS DETECTED ABOVE BACKGROUND IN ALLUVIAL GROUND WATER AT THE 903 PAD. MOUND, AND EAST TRENCHES

	-	Maximum compound concentrations determined from data collected through the second quarter of 1969.
В	-	Compound also present in blank.
J	-	Estimated below detection limit.
U	-	Detection limit.
A	-	Accepted with qualifications
NS	-	No ARAR Standard
mrem/yr	•	Millirem per year
•	-	Constituent reported below contract required detection limit.
**	•	MCL was published January 30, 1991, (56 <u>FR</u> 3526) with an effective date of July 30, 1992. Because these new standards will become
		ARAR on the effective date, these MCLs have been identified whenever they will cause a change in the ARAR.
***	•	MCL/MCLG change was published June 7, 1991, (56 <u>FR</u> 26460) with an effective date of November 1991. Because these new standards

will become ARAR on the effective date, they have been identified whenever they will cause a change in the ARAR.

of acceptable contaminant concentrations in soils to ensure environmental "protectiveness." This is discussed further in Section 7.5. ARARs addressing contaminants in air will be included in the CMS/FS Report. In general, federal and state standards for air exist only as source- or activity-specific requirements and, accordingly, will be addressed in detail in the FS process.

Surface water stations in the streams, ponds, and ditches in the OU No. 2 study area are considered to be part of OU Nos. 5 and 6. Seeps, however, are considered part of OU No. 2 as they represent ground-water discharge locations. These seeps, therefore, are treated as points at which to evaluate ground-water quality for the purposes of this work plan. Accordingly, no discussion of ARARs relative to surface water is presented in the section. Ground-water seeps, their impact on surface waters, streams, and compliance with surface water ARARs is a subject of the OU Nos. 5 and 6 RFI/RI work plans.

7.2 THE ARAR PROCESS

7.2.1 ARARS

"Applicable requirements," as defined in 40 CFR 300.5, are "those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be 'applicable." "Relevant and appropriate requirements," also defined in 40 CFR 300.5, are "those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate." The most stringent promulgated standards are applied as ARAR (Preamble to NCP, 55 FR 8741).

7.2.2 TBCs

In addition to ARARs, advisories, criteria, or guidance may be identified TBC for a particular release. As defined in 40 CFR 300.400(g)(3), the TBC category consists of advisories, criteria, or guidance developed by EPA, other federal agencies, or states that may be useful in developing remedies. Use of TBCs is discretionary rather than mandatory, as opposed to the use of ARARs, which is mandatory.

7.2.3 ARAR Categories

In general, there are three categories of ARARs. These categories are:

- 1. Ambient or chemical-specific requirements.
- 2. Location-specific requirements.
- 3. Performance, design, or other action-specific requirements.

ARARs are generally considered to be dynamic in nature in that they evolve from general to very specific in the CERCLA site clean-up process. Initially, during the RI work plan stage, probable chemical-specific ARARs may be identified, usually based on a limited amount of data. Chemical-specific ARARs at this point have meaning only in that they may be used to establish appropriate detection limits so that data collected in the RI will be amenable for comparison to ARAR standards. Identified potential chemical-specific ARARs may be modified if they are found to be inappropriate any time in the RFI/RI process. For example, chemical-specific ARARs could be deleted based on the absence of a constituent in analytical data obtained during the investigation.

It is also appropriate to identify location-specific ARARs early in the RI process so that information may be gathered to determine if restrictions have been placed on the concentration of hazardous substances or on the conduct of an activity solely because it occurs in a special location. As discussed in the introductory paragraph to this section, detailed location-specific ARARs will be proposed in the RFI/RI Report. Identification of action-specific ARARs and remediation goals is part of the FS process and will be addressed in the CMS/FS Report. For the proper management of investigation-derived wastes, as required in the IAG, Attachment 2, Statement of Work, Section IV, DOE has developed SOPs for field investigation activities. All waste generated by the various investigations conducted at Rocky Flats Plant will be managed in accordance with the SOPs. The SOPs satisfy the IAG requirement to comply with ARARs as they relate to investigation activities. Development of an overall site-wide approach to managing investigation-derived wastes is consistent with EPA policy (EPA, 1991).

7.2.4 Feasibility Study ARAR Requirements

Development of a preliminary list of potential chemical-specific ARARs in the RI process also allows the establishment of a list of preliminary remediation goals in the early FS process, which is essentially a tentative listing of contaminants together with initially anticipated clean-up concentrations or risk levels for each medium. Preliminary remediation goals serve to focus the development of alternatives on remedial technologies that can achieve the remediation goals, thereby limiting the number of alternatives to be considered in the detailed remedial alternative analysis, conducted later in the FS process. As more information becomes available during

the RI stage, chemical-specific ARARs may become more refined as constituents are added or deleted. Once data collection is complete, revised chemical-specific ARARs may be proposed.

When the data collection is complete, it is also appropriate to refine location-specific ARARs that may affect the development of remedial alternatives. In addition, during development of remedial action alternatives at the beginning of the FS process, a preliminary consideration of action-specific ARARs will be conducted. As remedial alternatives are screened during the FS, action-specific ARARs will be identified. When a detailed analysis of the remedial alternatives is conducted, all action-specific ARARs are refined and finalized with respect to each alternative before a comparison of alternatives begins. At this point, a discussion is provided in the FS report for each remedial alternative regarding the rationale for all ARAR determinations.

7.3 REMEDIAL ACTION AND REMEDIATION GOALS

CERCLA §121 specifically requires attainment of all ARARs. Moreover, as explained in the preamble to the NCP (55 FR 8741), in order to attain all ARARs a remedial action must comply with the most stringent requirement, which then ensures attainment of all other ARARs. Furthermore, CERCLA requires that the remedies selected must attain ARARs and be protective of human health and the environment. Consequently, preliminary remediation goals based on ARARs will require modification as new information and data are collected in the RI, including the baseline risk assessment (to be conducted), when ARARs are not available or are determined to be inadequate for protection of human health and the environment.

Development of remediation goals is actually a portion of the overall development of remedial action objectives, which ultimately will define the required endpoint of the selected remedial action. As stated in the preamble to the NCP (55 FR 8713), "remedial action objectives are the more general description of what the remedial action will accomplish. Remediation goals are a subset of remedial action objectives and consist of medium-specific or operable unit-specific chemical concentrations that are protective of human health and the environment and serve as goals for the remedial action. The remedial action objectives ... should specify: (1) the contaminants of concern, (2) exposure routes and receptors, and (3) an acceptable contaminant level or range of levels for each exposure medium (i.e., a preliminary remediation goal)." According to 40 CFR 300.430 (e)(2)(i), "Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment and shall be developed by considering the following":

ARARs (chemical-specific)

- Acceptable exposure levels for systemic toxicants.
- Acceptable exposure levels for known or suspected carcinogens.
- Technical limitations (e.g., detection limits).
- Uncertainty factors.
- Other pertinent information.

- Maximum Contaminant Level Goals (MCLGs) (or MCLs) where MCLGs are zero where relevant and appropriate.
- Acceptable exposure levels where multiple contaminants or multiple exposure pathways will
 cause exposure at ARAR levels resulting in cumulative risk in excess of 10⁻⁴.
- CWA AWQC, where relevant and appropriate.
- A CERCLA Alternative Concentration Limit (ACL) established pursuant to CERCLA § 121(d)(2)(B)(ii).
- Environmental evaluations, performed to assess specific threats to the environment.

Once a preferred remedial action alternative is formally selected, all chemical-, location-, and action-specific ARARs have also been defined in final form. If it is found that the most suitable remedial alternative does not meet an ARAR, the NCP at 40 CFR 300.430 (f)(1)(ii)(C) provides for waivers of ARARs under certain circumstances, such as technical impracticability, risk, or inconsistent application of state requirements. From this point, the alternative will become the final remedy as it is incorporated into the ROD. Once the final ROD has been signed, requirements may be modified only when they are determined to be applicable or relevant and appropriate and necessary to ensure that the remedy is protective of human health and the environment [40 CFR 300.430(f)(1)(ii)].

7:4 OU NO. 2 ALLUVIAL GROUND-WATER ARARS

The ARARs for alluvial ground water listed in Table 7-1 were developed using the ARARs rationale described above and were identified by examining the following promulgated standards:

- SDWA MCLs.
- RCRA 40 CFR Part 264 Subpart F concentration limits.
- Colorado WQCC Standards for Ground Water

7.4.1 Safe Drinking Water Act MCLs

SDWA MCLs represent the maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system [40 CFR 141.2(c)]. Because ground water at OU No. 2 is a potential source of drinking water, MCLs are ARAR. Furthermore, the NCP [40 CFR 300.430 (e)] requires that, in development of remediation goals for evaluating alternatives for final remediation, the following be considered for current or potential sources of drinking water: attainment of MCLGs or MCLs, if MCLGs are zero; and attainment of CWA AWQC, where relevant and appropriate. Because ground water at OU No. 2 is a potential source of drinking water, the MCLGs (or MCLs) are relevant and appropriate and should be attained

(note: the MCLGs are currently zero or equal to the MCLs). It should be noted that on January 30, 1991, and June 7, 1991, (56FR 3526 and 56 FR 26460, respectively) EPA published final rules amending MCLs and MCLGs for a number of the constituents identified in Table 7-1. These standards are effective July 30, 1992, and November 6, 1992, respectively, and will be regarded as relevant and appropriate at that time. For purposes of this work plan, the new MCLs (new MCLGs are zero or equal to the MCLs, except in the case of copper), are, therefore, proposed TBC and are identified as such in Table 7-1.

7.4.2 RCRA 40 CFR Part 264 Subpart F Concentration Limits

Owners or operators of facilities that treat, store, or dispose of hazardous waste must ensure that hazardous constituents listed in 6 CCR (Colorado Code of Regulations) 1007-3 and 40 CFR 261 Appendix VIII entering the ground water from a regulated unit do not exceed concentration limits (6 CCR 1007-3 and 40 CFR 264.94) at the point of compliance in the uppermost aquifer. The concentration limits include standards for 14 compounds (these standards are equivalent to and a subset of SDWA MCLs and are identified at 40 CFR 264.94, Table 1), with background or ACLs used as the standards for the other RCRA 40 CFR Part 261 Appendix VIII constituents or 40 CFR Part 264 Appendix IX constituents. These concentration limits apply to RCRA "regulated units" subject to permitting (defined at 40 CFR 264.90 to include landfills, surface impoundments, waste piles, and land treatment units) that received RCRA hazardous waste after July 26, 1982. Although OU No. 2 does not contain RCRA-regulated hazardous waste management units, it does contain IHSSs. As a result, these RCRA 40 CFR Part 264 Subpart F regulations are considered relevant and appropriate for ground water.

As discussed above, an ACL may be established for a hazardous constituent if it is determined that attainment of a Subpart F Table 1 constituent standard or background standard is not necessary to ensure adequate protection of human health and the environment. Furthermore, EPA has stated that for potential drinking water sources, the Agency's preference is to set remediation levels that are the equivalent of exposure- or health-based ACLs under RCRA (EPA, 1988d). Therefore, it is inappropriate to establish background as an ARAR unless it may be determined through risk assessment that attainment of background is necessary for adequate protection of human health and the environment. Accordingly, hazardous constituent background values will be applied as TBC until such time as risk assessment information indicates some other alternative standard is necessary to ensure "protectiveness." Alternatively, the 40 CFR 264.94 Table 1 standards are considered to be relevant and appropriate. Table 7-1, however, will identify SDWA MCLs rather than RCRA 40 CFR 264.94 Table 1 standards because the RCRA standards are currently equivalent and a subset of the SDWA MCLs. TBC background ground-water values for Subpart F are applied using maximum concentrations from background ground water in both the alluvial and bedrock lithologies at Rocky Flats Plant.

7.4.3 Colorado WQCC Standards for Ground Water

The Colorado WQCC has established both state-wide and classification-specific standards for the protection of state ground waters. State-wide standards currently exist for certain radioactive materials and organic pollutants (see Section 3.11.0, 5 CCR 1002-0). These standards are not currently independently enforceable. The standards may be enforced by application under other Colorado environmental regulatory programs, through such enforceability remains questionable as to whether enforcement under other Colorado regulatory programs could satisfy the requirements of the NCP, 40 CFR 300.400 (g)(4). Therefore, WQCC state-wide ground-water standards have been applied as TBC in Table 7-1.

The WQCC classification-specific ground-water standards do not appear to meet the NCP criteria for state ARARs. On March 15, 1991, the Colorado WQCC issued ground-water classifications and standards for ground waters at Rocky Flats Plant, effective April 30, 1991 (see Section 3.12.0). These classifications and standards may be enforceable in the future through the State Discharge Permit System regulations anticipated to become effective in July 1992 (see Section 6.1.0, 5 CCR 1002-2). Also, the Rocky Flats Plant site-specific standards do not meet the general applicability requirement of the NCP since no other state ground waters have been similarly classified. Accordingly, the Rocky Flats site-specific standards have also been applied as TBC in Table 7-1.

7.4.4 CWA Ambient Water Quality Criteria

The CWA AWQC are non-enforceable guidance developed under CWA Section 304, and are used by states in conjunction with designated stream segment usages to establish water quality standards for the protection of aquatic life and for the protection of human health. Standards include those established for drinking water and fish consumption, fish consumption only, as well as standards for the protection of aquatic life. CERCLA Section 121(d) requires that CWA AWQC be considered, where relevant and appropriate, in the development of remediation goals in the FS process. Relative to this work plan, AWQC in the form of drinking water and fish consumption may be considered relevant and appropriate for the ground-water medium being investigated. These AWQC will require consideration in the development of remediation goals for OU No. 2 and, accordingly, have been identified as TBCs for alluvial ground water.

It is important to note, however, as discussed in Section 7.4.3, that the Colorado WQCC has issued standards determined by the state to be appropriate and necessary for the protection of ground water at the Rocky Flats Plant. Although not yet ARAR because they are not yet of general applicability, the WQCC site-specific standards that reflect the specific conditions may result in a determination that other standards of a broader nature are not relevant and appropriate. Consequently, it is unlikely that CWQ AWQC will be considered relevant and appropriate for OU No. 2 ground water when remediation goals are established.

7.5 OPERABLE UNIT NO. 2 SOIL ARARS

As discussed in Section 7.1, one medium for which chemical-specific ARARs do not currently exist is soils;

however, a risk assessment will be performed to determine acceptable contaminant concentrations in soils to

ensure environmental "protectiveness." At this time, with respect to establishing analytical detection limits for

soils, use of the method detection limits provided in the GRRASP (EG&G, 1990k), which are CLP contract

required quantitation limits, should enable meaningful interpretation of soil sample results.

7.6 OU NO. 2 ARARS SUMMARY

Table 7-1 shows that certain volatile organics, metals, and major ions that were analyzed have exceeded

potential chemical-specific ARARs at some locations within OU No. 2. This does not indicate releases of these

constituents are occurring, since the concentrations of some substances may be due to past releases or to

natural geochemical processes. The listing of Table 7-1 has been presented to identify parameters for which

analysis should be conducted in the Phase II RFI/RI, and to identify the minimum acceptable detection limits

for analytes found in OU No. 2 alluvial ground water. The FS will evaluate technologies that address these

constituents.

The standards identified as ARARs in Table 7-1 are based on the most stringent standards found in the SDWA

MCLs, the environmental regulatory program determined to be either applicable or relevant and appropriate

to OU No. 2 alluvial ground water.

The standards and criteria identified as TBC in Table 7-1 are based on the most stringent standards found in

RCRA 40 CRF Part 264 Subpart F and Colorado WQCC State-Wide and Site-Specific Standards for Rocky Flats

Plant Ground Water. Additionally, wherever other TBC standards which are more appropriate, CWA AWQC

were identified in Table 7-1 only when no ARAR standards were found. The single exception to this is where

not yet effective SWQC MCL/MCLG changes exist as disucssed in Section 7.4.1. which will become ARAR

when effective.

Of the elements/compounds detected in ground water at OU No. 2, there are no ARARs or TBCs for calcium,

magnesium, molybdenum, potassium, sodium, or strontium. However, the TDS TBC provided by the WQCC

Ground Water Standards establishes the acceptable aggregate concentration for the major metal ions

(excludes strontium and molybdenum).

For any contaminants detected in ground water for which no ARARs or TBCs were found, use of the analytical

methods that achieve the detection limits provided in the GRRASP (EG&G, 1990k), which are CLP contract

required quantitation limits, should enable meaningful interpretation of sample results. In addition, whenever

Final Phase II RFI/RI Work Plan (Alluvial) 903 Pad, Mound. East Trenches Areas Rocky Flats Plant. Golden, Colorado Technical Memorandum 1

a potential standard is below the GRRASP-derived detection limit, the detection limit has been used as the standard. Risk-based concentrations taken from the baseline risk assessment will establish the remediation goals for the trace metals and organics for which no potential ARARs could be identified, thus ensuring environmental "protectiveness."

The schedule for conducting the Phase II RFI/RIFS is summarized in Figure 8-1. The schedule includes both the alluvial and bedrock components of the RFI/RI and the CMS/FS activities. The time frames are in accordance with the IAG schedule.

As discussed in Section 5.0 (FSP), the RFI/RI for the alluvial characterization will be conducted in steps. Monitoring wells will be installed for plume characterization followed by the drilling and installation of borings and monitoring wells for source characterization. Borehole, ground-water, sediment, and surficial soil samples will be collected for chemical analysis. The data will be validated and evaluated for incorporation into the draft and final RFI/RI reports.

During RFI/RI report preparation, treatability studies will be in progress and the CMS/FS will begin. The CMS/FS will include remedial alternatives development and screening, and detailed analysis of alternatives. According to this schedule, nearly four years will elapse from the time this work plan is finalized until the final CMS/FS report is prepared.

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Final Phase II RFI/RI Work Plan (Alluvial) 903 Pad, Mound, East Trenches Area Rocky Flats Plant, Golden, Colorado, Technical Memorandum 1 eg&g\903pad\ou2-ph2\aug\sec-8.aug



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U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

PROPOSED PHASE II RFI/RIFS SCHEDULE

FIGURE 8-1

July, 1991

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The QAA for OU No. 2 and the QAPP will be submitted to EPA and CDH as controlled documents under separate cover. These documents will establish specific QA controls applicable to the field investigations for OU No. 2.

The following items will be presented in the QAA:

- ER Program organization and responsibilities.
- Data quality objectives.
- Analytical methods and detection limits for the FSP parameters.
- EG&G SOPs applicable to the field activities.
- Data reduction, validation, and reporting requirements and guidelines.
- Document control specifications.
- Information on sample containers, preservation, and holding times.
- Chain-of-custody protocol.
- Control of measuring and testing equipment.
- Handling, storage, and shipping of samples.
- Recordkeeping.

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ATTACHMENT 1.0
SURFICIAL SOIL SAMPLING PLAN

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GLOSSARY OF ACRONYMS

AEC	U.S. Atomic Energy
CDH	Colorado Department of Health
CSU	Colorado State University
EM	EG&G/Energy Measurements
HClO₄	Perchloric acid
HF	Hydrofluoric acid
HPGe	High Purity Germanium Gamma Detectors
IHSS	Individual Hazardous Substance Site
g	gram
kPa	kiloPascals
М	Molar
m <i>l</i>	milliliter
mph	miles per hour
nm	nanometer
OU	Operable Unit
pCi/ℓ	picoCuries per liter
pCi/g	picoCuries per gram
RFP	Rocky Flats Plant
rpm	revolutions per minure
TDR	Time Domain Reflectometry

1.1 STATEMENT OF THE PROBLEM

The contamination of surficial soils around Rocky Flats Plant by plutonium (Pu) oxides was mainly caused by leaking barrels of plutonium-contaminated oil in the area known as the 903 Pad (Krey and Hardy, 1970). Numerous studies (Krey and Hardy, 1970; Seed, et al., 1971; Poet and Martell, 1972; Johnson, et al., 1976; Little, 1980; Little, et al., 1980) concluded that surficial soils in the area east of the 903 Pad are contaminated with plutonium and americium (Am) due to wind dispersal of soil particles during cleanup operations. More recently, the Phase I RI for Operable Unit Number 2 (OU No. 2) (Rockwell International, 1987a) found that the concentrations of plutonium and americium were elevated in composite soil samples adjacent to Trench T-2 (BH25-87, BH 26-87, and BH27-87) and the Reactive Metal Destruction Site (BH28-87) T-1 (boreholes BH35-87 and BH36-87). In addition, the Phase I RI found occasional elevated concentrations of plutonium (> 0.05 picoCuries per liter (pCi/l) in filtered surface water samples from seeps (surface water sampling stations SW-50, SW-53, and SW-54) and in stream sediments [> 0.9 picoCuries per gram (pCi/g)] along Woman Creek (sediment sampling stations SED-25, SED-26, SED-29, and SED-30). It has been suggested that the source of the contaminated sediments is the surface soils from the 903 Pad area which are transported by wind. However, the elevated concentrations of plutonium in filtered and unfiltered seep waters above Woman Creek suggest that some of the plutonium may travel in surface and ground water. Also, soil sampling results indicate that the actinides are enriched near the soil surface. Further investigation is necessary to characterize the transport mechanisms that control the spatial and vertical distribution of these radionuclides.

1.2 OBJECTIVES

The objectives of the proposed work plan for the surficial soils are: to determine the spatial and vertical extent of plutonium and americium in surficial soils of the remedial investigation areas and in the buffer zone; to study the physicochemical association of plutonium and americium in surficial soils (static and mobile soil phases) above seeps SW-50, SW-53, and SW-54; to study the movement of both water and radionuclides (colloidal and dissolved) down the soil column; and to ascertain the hydrogeochemical relationships between the soil interstitial water and the seeps downslope.

1.3 SPATIAL DISTRIBUTION OF PLUTONIUM AND AMERICIUM EAST OF THE ROCKY FLATS PLANT

1.3.1 Geostatistical Kriging Approach

The spatial dependency and distribution of actinides in surficial soils will be studied through the use of geostatistical techniques. The key concept of geostatistics is the regionalized variable. The variable is a function describing the geographical distribution of an environmental contaminant, such as plutonium and americium, in the soil environment. A principal concern of geostatistics is to relate the results obtained from one method to that obtained from another method [i.e., Rocky Flats Plant (RFP) as compared to the Colorado Department of Health (CDH) soil sampling techniques]. These characteristics of geostatistics will allow the use of historical data together with results generated by Phase II investigations. For example, the spatial distribution of plutonium and americium in the soils collected using the Rocky Flats Plant method [Seed, et al., 1971, unpublished data collected 1975 through 1978, and annual soil sampling conducted at Rocky Flats Plant (Rockwell International, 1975 through 1986, 1987b, 1989 and EG&G, 1990a)], as well as aerial and surface radiological surveys conducted by EG&G/Energy Measurements (EM) in 1981 and 1989 (EG&G/EM, 1982 and 1990, respectively).

Kriging will be used to make spatial distribution (contour) maps. Unlike conventional contouring subroutines, kriging uses certain statistical optimal properties and provides measures of the error of the contoured surface. Kriging uses the information from the semivariogram to find an optimal set of weights that are used in the estimation of the surface at unsampled locations. The semivariogram describes the rate of change in a regionalized variable and measures the degree of spatial dependence between samples within geographical boundaries. The variogram splits the total variance in a data set into two parts. The first represents the spatial differences between the values of the samples taken at points separated by increasingly large distances, whereas the second represent local or short-range variances. The latter is called the nugget variance which represents random variance. Because the semivariogram is a function of distance, the weights change according to the geographical arrangement of the samples (Isaaks and Srivastava, 1989).

The need for better understanding of the spatial and vertical distribution of plutonium were recognized many years ago by the Committee Evaluation of Plutonium Levels in Soils within and surrounding a U.S. Atomic Energy Commission (AEC) Installation at Rocky Flats, Colorado (Seed, et al., 1971). They recommended that the mechanism of plutonium transport in soil be addressed, and the chemical form of plutonium in Rocky Flats Plant soils should be determined. In response to these recommendations both extensive and intensive studies were conducted.

The plutonium concentrations in soils east of the 903 Pad clearly suggest a spatial trend from west to east (Figure 1-1). The strong west-east vector suggests that wind is the most probable force that controlled plutonium transport across the landscape.

Experimental semi-variograms consist of three parameters: sill, range, and nugget. The sill is defined as the maximum value in the semi-variogram where y(h) = C for $h \ge a$. The value h = a is called the range and is the maximum separation distance for which sample pairs remain correlated. In most soil studies y(h) will remain nonzero as h approaches zero, which is called the nugget effect $[y(h) = C_0, h > 0]$. It reflects the inherent random variation of a contaminant dispersion in the environment that cannot be predicted by any method and/or variability between sampling points at a distance less than that actually used or available. The variogram computation suggests a gaussian model with nugget of 0.34, sill of 0.71 and a range parameter of 1,237 (Figure 1-2). The gaussian model was computed using the following formula:

$$\gamma(h) = C_0 + C[1-\exp(-h^2/A_0^2)]$$

where

y(h) = variogram,

(h) = lag interval,

C₀ = nugget variance,

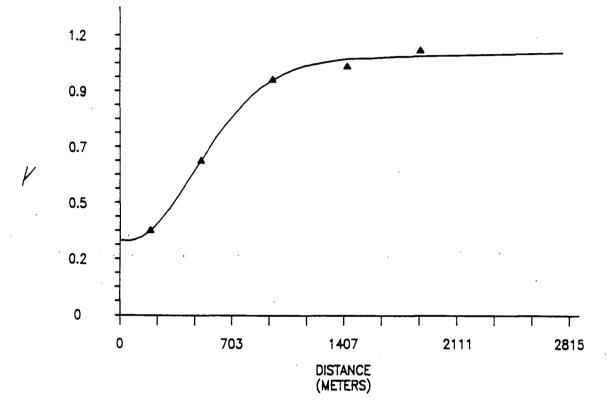
C = sill, and

A₀ = range parameter.

Kriging estimates using the gaussian model were computed for the extensive study sites and are depicted in Figures 1-1 and 1-3. Figure 1-1 depicts contours of soil-plutonium estimates in the buffer zone east of the 903 Pad. Kriging permits one to estimate the variance of each estimated mean and hence to assess whether additional data are needed in a given area. The main sources of the error estimates are: (1) number of the nearby samples, (2) proximity of the available samples, (3) spatial arrangement, and (4) the nature of the contaminant. Figure 1-3 illustrates the kriging standard of error estimates, which are low in the center of the buffer zone, and which verify the goodness-of-fit of the kriging estimates in this location. However, large standard error estimates were observed near the 903 Pad and in the northeast and southwest corners of the grid (Figure 1-3). These findings strongly suggest that a larger data set is needed in order to better estimate the spatial distribution of plutonium east of the 903 Pad. It should be noted, however, that on numerous occasions soils east of the 903 Pad were collected for various reasons (e.g., EG&G/EM, 1990). The unpublished data collected in 1975 to 1978 was used in the above kriging computation because of its inherent consistency (sampling, handling, and analysis of the soils, and excellent geographic distribution of the soils).

The traditional method of mapping (hand-contouring or computer generated contour maps) usually produces smooth contours that honor the data at known points. These techniques usually produces fairly erratic





THE VARIOGRAM (/) MEASURES THE DEGREE OF CORRELATION AMONG PLUTONIUM VALUES IN A GIVEN AREA AS A FUNCTION OF DISTANCE AND DIRECTION BETWEEN SAMPLES.

U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

ISOTROPIC SEMIVARIOGRAM

FIGURE 1-2

July, 1991

contours. Geostatistical techniques will produce a much smoother map that shows the <u>general trend</u> of a given pollutant (e.g., Figure 1-1). In addition, kriging will provide an estimate of the errors of estimation for the general trend (Figure 1-3) as well as the correlation between sample values at the sampling interval used. A cross section through the traditional map will show the variations in concentrations necessary to fit a smooth curve through the data, whereas the kriged section line will show a broad general trend and differs from the data by an average amount corresponding to the nugget effect. Hence, one should not expect to see a kriged contoured map that precisely matches all the observed points, but rather the best linear, unbiased estimate of the general trend of plutonium and americium in the soil environment east of 903 Pad. [An in-depth discussion of geostatistics and precise definition of the various terms used are presented in the introductory textbook (Isaaks and Srivastava, 1989).]

1.3.2 Source of Kriging Variations in Soil-Plutonium Concentrations in Surface Soils

In constructing these spatial distribution estimates the area immediately adjacent to the 903 Pad was excluded from the kriging analysis because of extremely large variations in soil-plutonium (Table 1-1). Hence, the contours of soil-plutonium depicted in Figure 1-1 provide a somewhat skewed distribution of soil-plutonium away from the source. Little, et al. (1980) speculated that the large range in plutonium concentrations in Rocky Flats Plant soils may derive from many small plutonium particles agglomerated with large soil particles to form aggregates. In another site, (Aiken, South Carolina) concentrations of plutonium in soils especially near the source were also highly variable with coefficients of variation usually exceeding 1.0 (Pinder and Paine, 1980). They ascribed the variations in plutonium-239,240 to varying distance from point of release (75 percent), microtopographical variations (20 percent) and sampling error, which included subsampling and analytical error (5 percent).

1.3.3 Ground Based Gamma Survey

A ground-based gamma survey of the area east of the 903 Pad was conducted by EG&G/EM during the fall of 1990. The gamma emitting isotopes in the area east of the 903 Pad were measured by High Purity Germanium Gamma Detectors (HPGe). A 150 foot grid spacing was selected to provide 100 percent land coverage. The instrument height was set at 7.2 meters above ground surface. Count time was set at 15 minutes based on the size of the area and number of measurement points needed to be accomplished in a reasonable time frame. The Vehicle Mounted System, as set up, had a minimal detectable activity of 0.9 pCi/g for americium-241. These readings represent an averaged americium activity within the top 3 centimeters (cm) of the soil. Plutonium concentrations were derived from the linear relationship between americium and

TABLE 1-1
SOIL-PLUTONIUM CONCENTRATIONS IN SURFACE SOILS EAST OF THE 903 PAD

pCi/g

<u>Author</u>	Number of Samples	Standard <u>Mean</u>	Concentration <u>Deviation</u>	Concentration Range	Sample Collection Method*
Campbell (1984)	19	1,024	978	74 - 3,700	RFP
DOE (unpublished, samples collected and analyzed	10	267	173	2 - 566	RFP
in 1990)	10	147	90	8 - 283	CDH

Sample Collection Method RFP - Rocky Flats Plant

The soil samples are collected by driving a 10×10 centimeter (4 x 4 inches) cutting tool 5 centimeters (2 inches) into undisturbed soil. The soil sample within the tool cavity is collected and placed into a new 1-gallon metal can. Five subsamples are collected from the corners and the center of two 1-meter squares, which are spaced 1 meter apart. Each set of 10 subsamples is composited (5,000 cm³) for soil radionuclides analyses.

CDH - Colorado Department of Health

The soil samples are collected by driving a stainless steel sampling device $(5.08 \times 5.4 \times 0.25)$ centimeters; $2 \times 2 \cdot 1/8 \times 1/4$ inches) into an undisturbed soil. The soil sample within the tool cavity is collected and placed into a new 1-pint metal can. Twenty-five subsamples are collected from a regional sampling sector or 10-acre area within a specified parcel of land to yield a single composite sample. The sample locations should be more or less evenly spaced within the area. If a single sample is taken from a single sampling location, then the sampling location should be representative of the area of interest. CDH has a set of specific requirements for the sampling location: 1) undisturbed area by anything other than natural causes for as long as possible, preferably for several years, 2) the location is relatively flat, open terrain, and 3) the site does not lie in the shadow of a hillside or other topographic feature that altered wind pattern.

plutonium in Rocky Flats soils ([Pu] = 6.23 x [Am]; R. Reiman, 1991). This estimate takes into account the original isotope mix and mixture age (EG&G/Energy Measurements, 1990). Kriging estimates using the linear model were computed for americium and plutonium distributions east of the 903 Pad (Figures 1-4 through 1-7). The letters H and L in these figures represent higher and lower values than the adjacent contours. Locations that contained americium values of less than 0.9 pCi/g were not included in the kriging computations. The radiological data provides an excellent spaced grid for spatial estimation of radionuclides, thus relatively small error of estimates were observed near the 903 Pad (Figures 1-5 and 1-7). However, an extremely large reading of americium (91 pCi/g) was observed in one location (Figure 1-4) which reinforced the notion that the spatial distribution of radionuclides near the source point can be extremely erratic.

1.3.4 Proposed Work

In order to assess the extent of plutonium and americium (U) in surficial soils within the plant boundaries, samples will be collected across the area identified in Figure 1-8 consisting of approximately 800 acres. Figure 1-8 was constructed on the basis of the above literature review, data analysis of unpublished material (Figures 1-1 and 1-2), and *in situ* radiological survey measurements (Figures 1-4 through 1-7). The State of Colorado requires special techniques for construction on lands with plutonium concentrations greater than 0.9 pCi/g of dry soil. To evaluate the soil-plutonium values relative to this guideline, the CDH sampling protocol will be used.

The CDH sampling protocol requires 25 subsamples to be composited within a 10-acre area for analysis. Because of the large variations in soil-plutonium near the source area, a 2.5-acre grid will be sampled immediately east of the 903 Pad and around the East Trenches area (Figure 1-8). This sampling design will serve two purposes: (1) increase confidence in soil-plutonium estimates around 903 Pad and East Trenches Areas, and (2) expand the number of soil data for kriging estimates. The pedologic sampling in the 2.5-acre area will consist of 25 subsamples for plutonium and americium concentration determination. In addition, 25 subsamples will be composited within the 10-acre grid to assess the spatial distribution of plutonium and americium within the buffer zone east of the 903 Pad (Figure 1-8). The northwest corner of each grid will be surveyed and identified with an appropriately marked steel post. Grids will be oriented on the cardinal compass directions. The 25 subsamples for the composite samples will be located with a hand held compass and tape measure using the northwest corner as the starting point. If large concentrations of plutonium (> 10 pCi/g) are detected north of the Mound Area, 10 additional 10-acre plots will be added between the Mound Area and North Walnut Creek.

1.4 VERTICAL DISTRIBUTION OF PLUTONIUM AND AMERICIUM IN SOILS EAST OF ROCKY FLATS PLANT

1.4.1 Past Work

Several studies investigated the magnitude of plutonium transport down the soil column. The intensive study site, which is located approximately 1.5 kilometers east of the 903 Pad (Figure 1-1), was established in 1979 in response to the recommendations outlined by Seed, et al. (1971). Soil samples were collected between 1979 and 1983 to assess the vertical distribution of plutonium in Rocky Flats Plant soils (Rockwell International, 1985). Composite samples were collected from 60 2-square meter plots located 1 meter apart. Samples were taken from 0 to 5 centimeters and 5 to 20 centimeters intervals. The surface samples were collected using the Rocky Flats Plant method, whereas the subsurface samples were collected using a soil auger. The mean and the standard deviation of soil-plutonium concentrations in the surface and the subsurface horizons were 10.2 ± 2.7 pCi/g and 1.1 ± 0.4 pCi/g, respectively. The vertical profile of the data distribution suggests that some plutonium has migrated down the soil column. Little and Whicker (1978) found that plutonium concentrations in soils east of the 903 Pad increased with decreased particle-size. Their studies indicate that the highest plutonium concentrations were associated with sub-micron sized soil particles for all depths (0 to 21 centimeters). Two-thirds of the total plutonium in the soils were found in the top 5 centimeters. The relationships between plutonium concentrations and soil particle size suggests a surface-attachment mechanism of plutonium to soil particles. However, the absence of a consistent trend of soil-plutonium with depth for the various particle sizes indicates that vertical plutonium transport is not simple transport of plutonium down the soil column. For example, Krey, et al. (1978) found that 90 percent of total deposit of plutonium was held in the upper 10 centimeters of the soil. They recommended a more detailed study of soil characteristics and additional measurements of plutonium concentrations with depth and time at the Rocky Flats Plant

1.4.2 Proposed Work

Twenty-six soil profiles will be excavated, described, and sampled in order to assess the vertical distribution of plutonium-239,240 and americium-241 in soils east of the Rocky Flats Plant. Eleven soil profiles will be excavated in the immediate vicinity of the 903 Pad, East Trenches, and seep SW-53, and an additional 12 soil profiles will be excavated according to soil types, direction, and distance from the 903 Pad. Three profiles will also be located in the OU No. 1 Study area. The approximate location of soil profiles are depicted in Figure 1-8. The soil profiles will be dug in undisturbed or the least disturbed sites which are characterized by the natural short grass prairie, pasture, and valley side vegetation (Clark, et al., 1980). The exact location of the soil profiles will be determined in the field using aerial photographs, soil and topographic maps, radiological surveys, and common sense. Transport of soil-plutonium in the soil environment is highly affected by soil type,

moisture content, texture, structure, and particle characteristics such as shape, density, and cohesiveness (Burley, 1990). Hence, all the major soil types east of the 903 Pad will be sampled (Table 1-2). Soil profiles will be excavated in all soil types east of the 903 Pad to assess the vertical distribution of soil-plutonium.

Sampling soil profiles for radionuclides characterization is difficult for the following several reasons:

- Potential contamination of subsurface horizons during sampling from the highly contaminated surface horizons.
- Collection of sufficient sample material for actinides concentrations and other soil chemical parameters.
- Selecting the best sampling design to study the chemical trends in the soil profile with little or no cross contamination.

In light of these difficulties, special attention will be given to surficial soil sampling from the 26 soil profiles using a modified trench method (Harley, 1972). This method involves digging a trench with a backhoe or shovel 1.5 meters long, 1.0 meters wide, and 1.0 meters deep. One wall of the trench will be dug as a block/stair case (15 centimeters height each) to minimize cross contamination. The vegetation at the surface of the selected wall will be cropped closely to the surface and discarded. The soil morphology will be described according to the standard operating procedures for logging alluvial and bedrock material (SOP 3.1, EG&G 1990b). The surficial soil will be sampled at intervals of 3 centimeters starting at the deepest block/stair in a given pit. Surficial soil samples will be collected using a stainless steel scoop and template (3 centimeters x 20 centimeters) which will be pressed into the wall of the block/stair case. Three samples from each depth will be consolidated to provide a better representation of the site and to produce enough soil material for the various chemical analyses described below. After a sample has been collected, the soil layers below it will be cleared of slough to prevent possible contamination from falling soil material from the upper layer. A flag will be placed on the ground surface of a given pit and the depth below surface for each sample will be measured from the base of the flag. Upon completion of the sampling activities each pit will be backfilled with the original soil mixture removed during the excavation.

A site-specific Health and Safety Plan will be developed for the Phase II RFI/RI field activities. The plan will specify stabilization procedures during excavation and surficial soil sampling events to prevent resuspension of particulates. Tarps will be used to cover soil piles and water will be applied to access roads and excavation sites to control dust. Excavation activities will not proceed when sustained wind velocities exceed 15 miles per hour (mph).

TABLE 1-2
SOIL TYPES EAST OF THE 903 PAD

Series	Family	Phase	Nin-Hax Slope (%)	Infiltration Rate	Soil Type*
Denver	Torrertic Arguistolls	clay loam	5-9	slow	27
Denver-Kutch	Torrertic Arguistolls	clay loam	5-9	slow	29
Denver-Kutch- Midway	Torrertic Arguistolls	clay loam	9-25	slow	31
Englewood	Torrertic Arguistolls	clay loam	2-5	slow ,	42
Flatirons	Aridic Paleustols	sandy toam	0-3	slow	45
Haverson	Ustic Torrifluvents	loam	0-3	moderate	60
Leyden- Primen- Standley	Aridic Arguistolls	cobbly clay loam	15-50	slow	80
Midway	Ustic Torriorthents	clay toam	9-30	slow	98
Nederland	Aridic Arguistolls	sandy loam	15-50	moderate	100
Nunn	Aridic Arguistolls	clay loam	0-2	slow	102
Nunn	Aridic Arguistolls	clay loam	2-5	slow	103
Standley-Nunn	Aridic Arguistolls	gravelly clay loam	0-5	slow	149
Willowman- Leyden	Aridic Arguistolls	clay loam	9-30	moderate	174

[•] Soil Type number corresponds to soil type exhibited in Figure 1-8.

Source: U.S. Department of Agriculture, 1980

1.5 PHYSICOCHEMICAL ASSOCIATION OF PLUTONIUM IN ROCKY FLATS PLANT SOILS

1.5.1 Static Soil Phase - Past Work

Sorption of plutonium (IV) onto mineral surfaces, complexation with naturally occurring organic substances, and carbonate species are the dominant processes in plutonium cycling in the soil environment (Polzer, 1971; Bondietti, et al., 1976). Plutonium in oxidation state (IV) is very insoluble in water in the absence of complexing agents (Bondietti and Tamura, 1980). Onishi, et al. (1981) reviewed radionuclide adsorption/desorption mechanisms in soils and concluded that strong adsorption of plutonium occurs over the pH range of 4 to 8 and is easily complexed with humic acids, oxalate, and acetate ions. Bondietti, et al. (1976) removed 82 percent of the soil-plutonium by repeated bleaching experiment with NaOCl at pH 9.5, which minimized inorganic mineral destruction (Lavkulch and Wiens, 1970), and thus would not extract occluded plutonium in sesquioxides. This removal suggests that a large portion of soil-plutonium is associated with organic carbon (C), and that plutonium is associated with the soil via surface-sorbed mechanisms. The release of organic chelates agents is strongly dependent on pH and decalcification processes within the soil (Bondietti and Tamura, 1980).

The Phase I RI found occasional elevated concentrations of plutonium (> 0.05 pCi/l) in seep waters (SW-50, SW-53, and SW-54) (Rockwell International, 1987a). Although the total concentration of plutonium in the soil matrix is important information in appraising the potential hazard, total concentrations do not provide sufficient data to assess potential transport and availability of plutonium in the soil environment. Hence, in order to better understand the mechanisms of transport of plutonium in soils and seep waters, a sequential extraction of soil from five soil profiles above seep SW-53 (locations X1 to X5; Figure 1-9) will be conducted. Soil samples will be collected at 3 to 5 centimeters intervals. The procedure for sampling the soil profiles is described above. This study, in conjunction with the soil interstitial waters investigation (Mobile Soil Phase, see below), will provide the necessary information to appraise the nature of plutonium transport in the soils of Rocky Flats.

1.5.2 Static Soil Phase - Sequential Extraction Experiments

Use of total plutonium concentrations as a criterion to assess the potential effects of soil contamination implies that all forms of plutonium have an equal impact on the environment. It is clear that such an assumption is untenable. Kochen, et al., (unpublished) assumed that plutonium has been adsorbed to clay, organic matter, and/or sesqueoxides (e.g., Fe₂O₃-PuO₂). However, no direct measurement was conducted to quantify the type and degree of plutonium adsorption to the various mineralogical phases. Conceptually, the soil can be partitioned into specific fractions which can be extracted selectively by using appropriate extractants (Tessier, et al., 1979). Sequential multiple dissolution techniques which selectively extract soil material with resulting release of its associate metals have been extensively used in soil science and geochemical exploration (Chao.

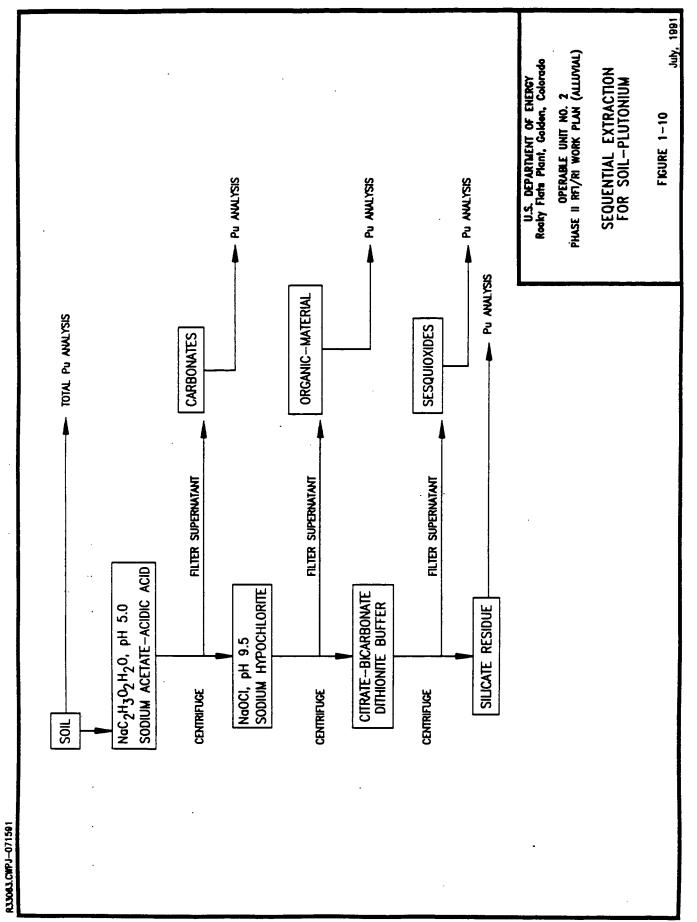
1984). The purpose of the selective sequential extraction in the proposed study is to elucidate the mode of occurrence and possible transport of plutonium and americium in soils. It should be noted, however, that the partitioning of plutonium and americium obtained by this procedure is operationally defined, as it is influenced by experimental factors such as the choice of reagents, the time of extraction, and the ratio of extractant to soil (Tessier, et al., 1979). In addition, inherent analytical problems such as incomplete selectivity and readsorption may seriously affect the extracted metal concentrations. For example, Rendell, et al. (1980) found that added cadmium (Cd), lead (Pb) and copper (Cu) were readsorbed by uncontaminated river sediments during overnight extraction with selected extractant solutions. Gruebel, et al. (1988) showed that arsenic (As), and selenium (Se), associated with freshly precipitated amorphous iron oxides, were readsorbed onto other minerals unaffected by the reductive extractant. Kheboin and Bauer (1987) doped trace metals into humic acid, iron sulfides, calcite, and iron hydroxides but failed to recover Cu, Zinc (Zn), Pb, and Cu and Nickel (Ni), respectively in the appropriate fraction using the selective procedure outlined by Tessier, et al. (1979). These findings imply that selective extraction may not be suitable for distinguishing the phase-association of metals in soils. Belzlle, et al. (1989) have challenged the above results and asserted that postextraction readsorption of metals occurred due to improper experimental conditions of the sequential extraction and mineral phases. They quite convincingly showed that trace elements spikes (< 100 percent of the amount present in the control samples) were recovered within the limits given by the experimental errors ± 10 percent.

1.5.3 Static Soil Phase - Proposed Work

Plutonium determination will be performed on four sequential, selective extracts in triplicates to assess the physicochemical association of plutonium with calcium carbonate (CaCO₃), organic carbon, sesquioxides, and residue (Figure 1-10). In this study the gamma emitting isotope shall be utilized, plutonium-237, as a tracer to assess the degree of postextraction readsorption of plutonium during the various extractions performed on the soils. In addition, the sequence of extractions shown in Figure 1-10 will be modified to test the uniqueness of an individual extraction.

1.5.3.1 Tracer Study

Spikes of plutonium-237 will be added to soil samples (triplicates) before each extraction step (Figure 1-10). The distribution of plutonium-237 in the various soil phases and solution, and the possible readsorption of the tracer, will be carefully determined. Plutonium-237 tracer is ideal for this work since its 60 KeV γ emission can be efficiently measured externally using a GeLi detector and a multichannel analyzer (non-destructive technique). This tracer has a physical half-life of sufficient length (45 days) to permit easy measurements over the course of the experiment, yet short enough to decay reasonably rapidly. The basic assumption underlying the validity of the plutonium-237 tracer experiments is that the behavior of plutonium-237 is identical to plutonium-239, 240 present in soil. Theoretically, the difference in mass between isotopes can cause a shift



in the reaction rate or equilibria (the isotope effect). Because the degree of chemical bond stability is directly related to the square root of the mass of the isotopes involved, it is apparent that the isotope effect will not be of significance for high atomic weight elements like plutonium. The plutonium-237 tracer will be added in a chemical and physical state similar to that of plutonium-237 to ensure complete isotopic exchange between isotopes in the experimental system. Similar data can be obtained for americium-241 since it is also a gamma emitter.

In case of serious postextraction readsorption (> 15 percent) the selective sequential extraction will not be performed. In case the selective sequential extraction procedure is rejected, samples collected from pits X1 to X5 will only be analyzed for total plutonium.

1.5.3.2 Partitioning of Soil Phases

Fraction 1. Carbonates. In the soil environment, carbonates are susceptible to changes in pH that will induce the release of adsorbed plutonium. Carbonates will be removed by 0.5 molar (M) sodium acetate-acetic acid buffer solution (NaC₂H₃O₂H₂O), adjusted to pH 5. This buffer treatment removes metals held in carbonates (coprecipitate with carbonates and/or adsorbed by iron and manganese (Mn) oxides which have precipitated onto the carbonates) (Jenne, 1977). This buffer apparently does no attack the resistant sesquioxide phases to any great extent and leaves the lattice structure of silicate minerals intact (Chao, 1984).

Fraction 2. Organic. In natural conditions, organic carbon is gradually decomposed which may lead to release of soluble and colloidal plutonium. The organic carbon will be extracted by NaOCI at pH 9.5. Lavkulch and Wiens (1970) removed up to 98 percent of the oxidizable organic carbon from 16 soil samples by 3 successive extractions with sodium hypochlorite. The sodium hypochlorite treatment is the preferable solution for extracting plutonium from soil organic matter because it does not appear to dissolve sesquioxide phases. It should be noted, however, that sodium hypochlorite will attack sulfides that may be present in the sample.

Fraction 3. Sesquioxides. Sesquioxides are excellent scavengers of trace metals and are extremely unstable under anoxic conditions. There are various techniques to extract iron (Fe), manganese, and aluminum (Al) oxides in soils. These methods were developed to selectively dissolve the various mineralogical forms and degree of fineness of the sesquioxides present in soils. In the context of the proposed study, the citrate-bicarbonate-dithionite buffer method (Jackson, et al., 1986) is superior to other methods because it dissolves amorphous sesquioxides completely whereas the highly crystalline sesquioxides (e.g., hematite and goethite) will be partially dissolved. The degree of dissolution of the highly crystalline sesquioxides is dependent on the crystallinity and the degree of grinding of the oxides. Hence, in order to obtain complete dissolution of crystalline sesquioxides, the soil samples will be finely ground and three multiple extractions will be performed.

<u>Fraction 4. Residue.</u> After removal of the above chemical phases from the soil sample, the residue consists of silicates and some other resistant mineral species such as ilmenite and magnetite. The residue will be dissolved by strong digestion with hydrofluoric acid in conjunction with perchloric acid.

1.5.3.3 Experimental Conditions

- (a) Bound to Carbonates. The soils will be extracted for 5 hours with 20 milliliters (ml) of 1M sodium acetate-acidic acid solution adjusted to pH 5.0. Detailed description of this extraction is given by Nelson (1982).
- (b) Bound to Organic. The residue from (a) will be extracted for 5 hours with 20 m² of 1M sodium hypochlorite solution adjusted to pH 9.5. Detailed description of this extraction is given by Hoffman and Fletcher (1981).
- (c) Bound to sesquioxides. The residue from (b) will be extracted for 6 hours with 100 ml of 0.3M sodium citrate mixed with 1M sodium carbonate solution and appropriate amounts of sodium dithinite and sodium chloride salts. This extract will be repeated three times to assure almost complete dissolution of highly crystalline iron oxides. Detailed description of the extraction is given by Jackson, et al. (1986).
- (d) Residual. The residue from (c) will be digested by a 5:1 mixture of hydrofluoric (HF) and perchloric (HClO₄) acids. For a 1-gram (g) (dry weight) sample, the soil will be first digested in a platinum crucible with a solution of concentrated HClO₄ (2ml) and HF (10ml) to near dryness. Subsequently, a second addition of HClO₄ (1ml) and HF (10ml) will be made, and again the mixture will be brought to near dryness. Finally, HClO₄ (1ml) will be added and the sample will be evaporated until the appearance of white fumes. Further details of this extraction is given by Lim and Jackson (1982).

After each extraction the sample will be centrifuged at 10,000 revolutions per minute (rpm) for 30 minutes. The supernatant will be removed with a pipet and prepared for plutonium and americium analysis. The residue will be washed with 10 ml of deionized water to remove residual salt from the previous extraction. The volume of the rinse water will be kept at a minimum to avoid excessive solubilization of organic matter.

In addition to plutonium and americium determination, the following laboratory analyses will be conducted on all samples from the 26 soil profiles: (1) total organic carbon; (2) pH; (3) calcium carbonate content; and (4) specific conductance. The specific conductance will be used to estimate the ionic strength of the soil slurry (Lindsay, 1979). All samples from the 26 profiles will also be subjected to the carbonate and organic carbon extraction experiments described above. Residual extractions will be performed to determine the percentages of primary and secondary minerals. The samples collected from pits X1 through X5 (Figure 1-9) will also be subjected to the sesquioxide and residual extraction experiments. Particle size analyses and bulk density testing will also be performed on samples from selected profiles. Specifically, a sample from a profile representative of each soil type (Table 2-2 and Figure 2-6 of the alluvial work plan) will be submitted for these geotechnical tests.

1.5.4 Mobile Soil Phase - Past Work

Reports of plutonium and americium movement in ground water over distances beyond several meters are rare. Hakonson, et al. (1981) reviewed the transport of plutonium in terrestrial systems and asserted that vertical leaching of soluble plutonium through the soil is a potentially important phenomenon. Onishi, et al. (1981) concluded that adsorbed plutonium can be readily moved through the aqueous environment in colloidal form. Recently, Penrose, et al. (1990) found that plutonium and americium were transported in ground water for at least 3,390 meters downgradient from the point of discharge where plutonium and americium were tightly or irreversibly bound to colloidal material [25 to 450 nanometers (nm)]. Krey, et al. (1978) attributed the successful application of the diffusion term in their soil-plutonium transport model, at several diverse sites east of the 903 Pad, to transportability of plutonium in soil interstitial waters and not to soil characteristics.

Little research has been conducted on the transport of actinides within the soils and to seeps and streams at the Rocky Flats Plant. Moreover, there are no studies on the physicochemical characteristics of interstitial waters in soils and sediments from Individual Hazardous Substance Sites (IHSSs) on plant site. The excavation of 26 soil profiles will allow for the installation of automated soil solution samplers in order to measure and characterize the movement of water and radionuclides down the soil column. More specifically, soil solution samplers will be installed in the soils above seeps SW-50, SW-53, and SW-54 to study the movement of both water and radionuclides (colloidal and dissolved) down the soil column and to the seeps downslope.

1.5.5 Mobile Soil Phase - Proposed Work

Environmental fate of actinides in soils are usually studied by extracting the soil matter. In general, these analyses fail to provide important information regarding the transport mechanisms of pollutants within the soil column. Hydrological analysis of the frequency, duration and intensity of summer precipitation events and spring snowmelt events, coupled with direct measurements of solute transport in soils, will provide essential information to assess the form and magnitude of actinide movement in soil.

The proposed research design is based on the following three hypotheses:

- Leaching episodes in the soils will transport solute and colloidally-bound actinides down the soil column.
- Freely flowing waters in the soil environment will carry different actinide concentrations than soil solutions collected at higher matrix potentials.
- The occasional elevated concentrations of plutonium in seep SW-53 were originated by vertical leaching of plutonium from the soil environment upslope.

Testing these hypotheses will require *in situ* sampling of soil interstitial waters over time. More specifically, it will be necessary to develop a fully-automated, remote-controlled soil solution sampling system that is capable of: (a) collecting freely flowing water [0-5 kiloPascals (kPa) matrix potential] mainly via macropores; (b) collecting soil solutions flowing in micropores at higher matrix potential (5-40 kPa); and (c) provide accurate and timely measurements of incoming precipitation. This apparatus will consist of five major modules: an automated zero-tension sampler, in which freely flowing water mainly in macropores (formed by frost heave cycles and swelling and shrinking of clays), will be accurately collected for assessing the subsurface flow during and after major precipitation events; a fluxmeter which will provide the unsaturated flux as the soil dries out as well as soil solutions for radiochemistry analyses; tipping bucket rain gauge; time domain reflectometry (TDR) soil moisture probes which will measure *in situ* soil water content; and telemetry communication which

will send the data collected in the field to a base station at T130B (Figure 1-11).

The objectives of the proposed work are to:

- Estimate the importance of vertical flow in the soil environment upslope from seep SW-53 during and after major precipitation events.
- Assess the relationships between soil-plutonium in the interstitial waters and plutonium in the seep SW-53.

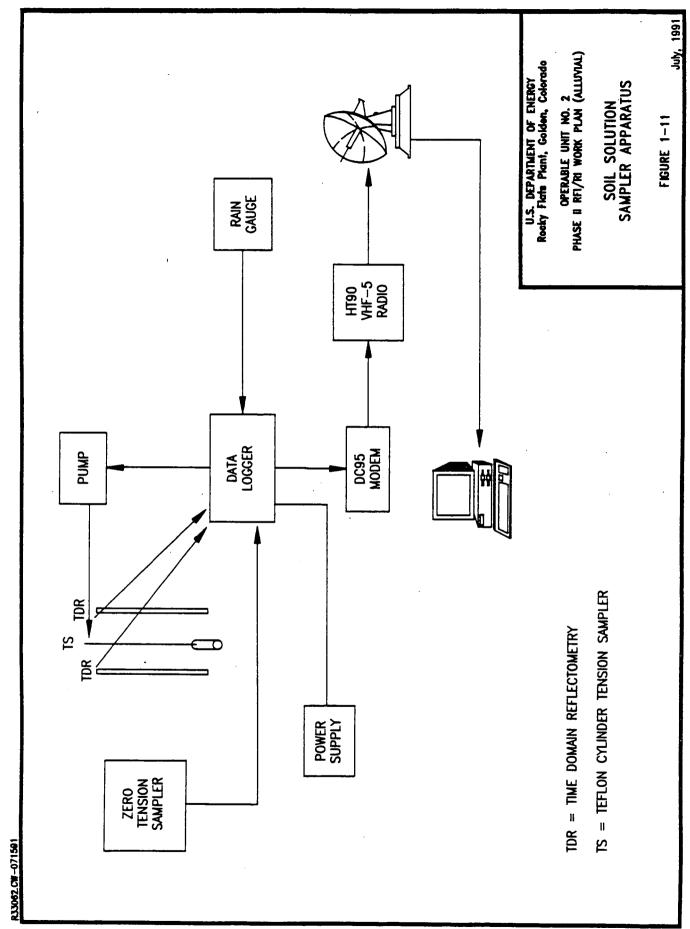
The water flow data obtained *in situ* will be used to test the infiltration rates and flow estimates for the unsaturated flow model, being developed by Colorado State University (CSU) (mid-1991), for the area east of the 903 Pad. The chemical characterization study will include: (1) total concentrations of plutonium and americium in soil interstitial waters that move freely (0-5 kPa) down the soil column, and (2) fractionation of actinides in colloidal and dissolved (< 0.1 micrometer [µm]) phases in freely flowing waters (0 - 5 kPa) and various matrix potentials (5 - 10; 10 - 30; 30 - 50 kPa).

1.5.5.1 Soil Solution Samplers

The chemical characterization will be performed using the soil solution sampler equipment described in the following sections. These samplers will include zero-tension samplers and fluxmeters.

Zero-tension sampler

The zero-tension sampler will be made of 40-centimeter segments of plexiglass (25 centimeter width) with one end plugged with a plexiglass stopper containing a collection tube and the other end sharpened. The sharpened end will be driven into the western pit face of pits X1 through X5 (Figure 1-9) with a mallet to ensure minimal structure and textural disturbance to the soil. The water sampled by the zero-tension sampler will be



Final Phase RFI/RI Work Ptan (Alluvial) - 903 Pad, Mound, and East Trenches Rocky Flats Plant, Golden, Colorado Technical Memorandum 1 eg&g\903pad\ou2-pn2\jiy\attch-1.jiy

collected by a 2-liter(*l*) bottle mounted on a load cell. The temperature of the soil interstitial waters and the soil matrix will be measured by a temperature probe. The temperature and amount of water in the collection bottle will be simultaneously transmitted to a data logger. The transmitted information will be transferred daily to the base station via telemetry. Sending the data via telemetry to the base station (trailer T130B) will provide crucial information regarding the time and frequency of field sampling.

The soil pits will be refilled after access tubes are inserted to prevent convergence flow and to minimize further disturbance. The zero-tension soil solution samplers will be installed upslope of seep SW-53 every 10 to 15 cm down the soil column to the depth of the caliche horizon or other semi-impermeable layer in the five soil pits.

Fluxmeter

The fluxmeter consists of three components: a Teflon cylinder soil water sampler which is treated with silica to reduce hydrophobicity; three TDR soil moisture probes; and a portable vacuum pump with a buffer container. Each Teflon sampler will be installed with three TDR soil moisture probes around it and connected, via Teflon tubing, to a 2-liter collecting bottle equipped with a special screw cap of polyethylene with teflon gasket and fittings. The 2-liter collecting bottles will be residing inside a thermo-box which will minimize temperature fluctuations in the field. Two types of Teflon cylinder soil water samplers will be used: a teflon cylinder with an average pore size of 10 micrometer for sampling large water volumes during short flow episodes; and a teflon cylinder with an average pore size of 5 micrometer for normal operational conditions. Ten Teflon cylinder soil water samplers will be installed at five different depths in each pit (X1 through X5; Figure 1-9) excavated for the zero-tension sampler. The Teflon cylinder soil water samplers will be installed into the face of the soil pit using a stainless-steel rod. The soil moisture probes will be connected via coaxial cable to a Tektronix cable tester, equipped with a communication interface, to a data logger (Figure 1-12). Once the moisture of the soil exceeds a pre-set value the vacuum pump will be activated to produce an equivalent vacuum inside the tension sampler. The equivalent vacuum will be derived from the linear relationships between soil moisture and matrix potential values in the range of 0.1 to 50 kPa.

The soil interstitial waters collected by the zero-tension samplers and the tension samplers will be filtered on the day of sampling using 0.45- and 0.1-micrometer Millipore filters. The total colloidal bound plutonium will be determined from the material that was retained on the filters. The dissolved plutonium will be determined from the water that passed through the filter.

The State of the S

1.5.5.2 Precipitation Events Simulation

The frequency, duration and intensity of summer precipitation will be determined by a tipping bucket rain gauge. This rain gauge is an integral part of the proposed apparatus and will be mounted in the middle of the transect. The rain gauge will simultaneously transfer the data to the data logger which will transmit this information via telemetry to the base station in T130B. The amount and nature of precipitation and soil water flux will be recorded and checked daily. The frequency of field sampling will be determined on the basis of the transmitted data. This data will be used to prepare a precipitation model for hydrologic simulation and analysis.

The amount of water that can be collected by this apparatus in Rocky Flats Plant soils is currently unknown. One to 2 liters of interstitial waters were collected every week during snowmelt and after every major precipitation event in forested and alpine ecosystems using a simplified version of the proposed apparatus (Litaor, 1988). Hence, two rain simulation experiments will be conducted before the beginning of the precipitation season. The first experiment will be used to verify that all the components of the apparatus are interfacing and communicating with each other and the base station. Calibration of the load cells and the TDR soil moisture probes will be performed during the first rain simulation experiment. The magnitude and duration of the last 5 years to determine the magnitude and duration of storm events. Soil solution collected during the second simulation experiment will be submitted for radionuclides analyses.

The importance of hydrologic model simulation of rain and snow precipitation in the proposed work can be summarized as follows: (1) rain simulation yields more rapid results, especially in the testing of the extreme conditions (e.g., rainfall in arid and semi-arid conditions); and (2) rain simulation is more controlled inasmuch as one can take appropriate measurements with selected intensities and durations. The rain simulator described by Ghodrati, et al. (1990) will be used in the proposed work. This rain simulator can employ spatially uniform application of water to small plots (1-2 square meters). The simulated rainwater will have the same ionic strength as the average rainwater observed at Rocky Flats Plant.

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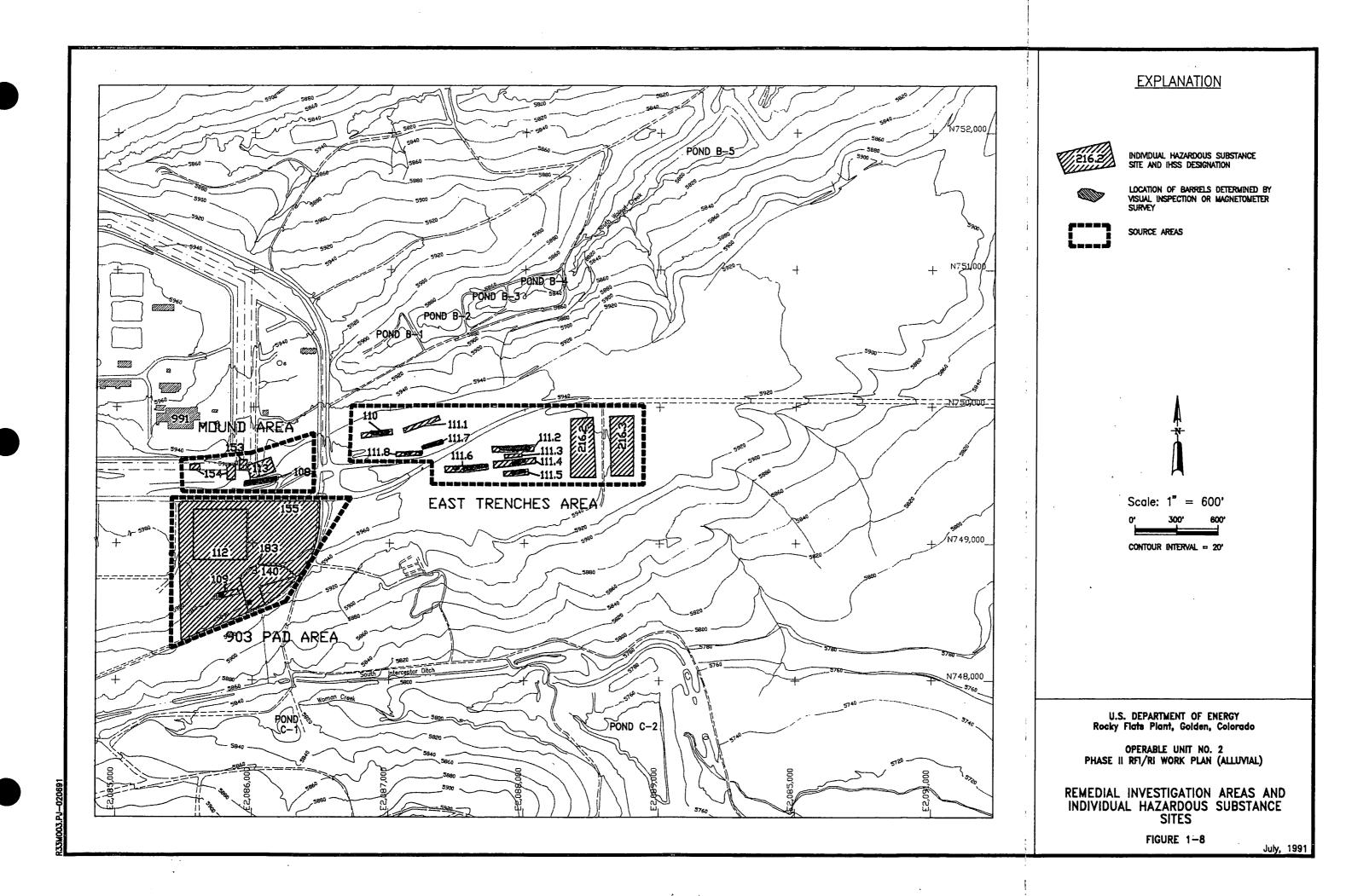
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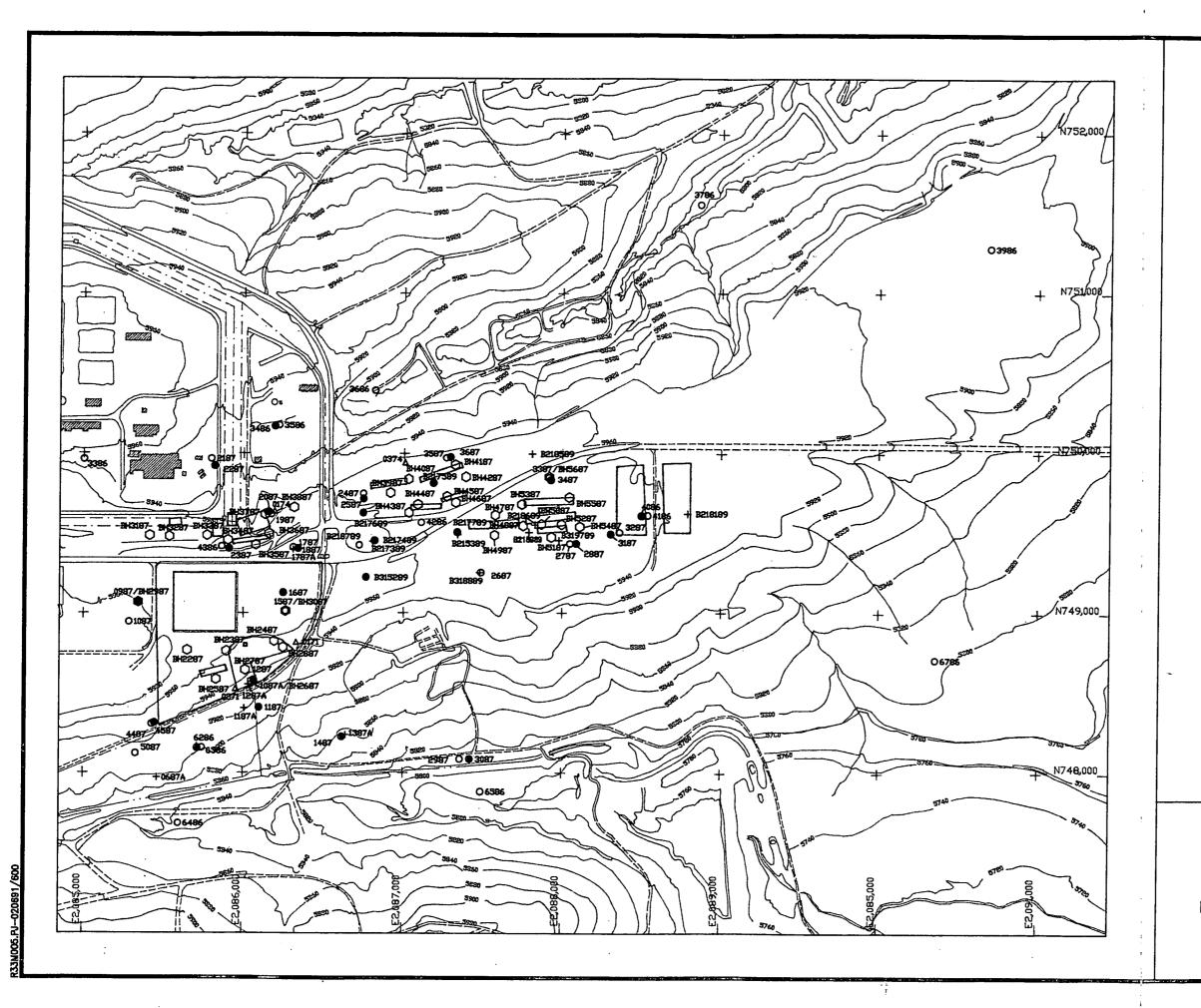
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Indimidual Hazardous substance site and IHSS designation

B217489 ● BEDROCK MONITOR WELL

B213789 O ALLUMAL MONITOR WELL

0392 A PRE-1986 MONITOR WELL

B217389 + ABANDONED HOLE

BH4987 O BOREHOLE



Scale: 1" = 600'

0' 300' 600'

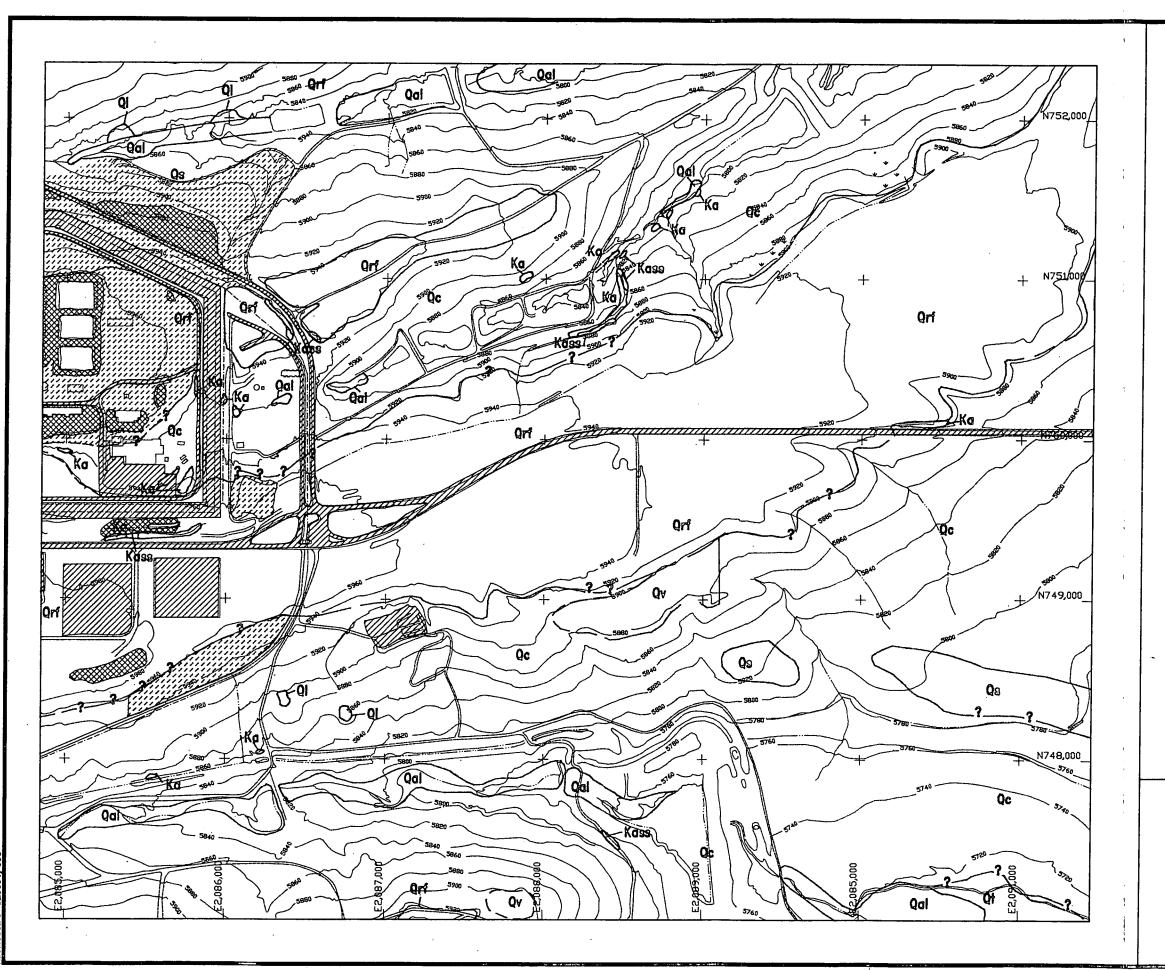
CONTOUR INTERVAL = 20'

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OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

PHASE I REMEDIAL INVESTIGATION MONITOR WELL AND BOREHOLE LOCATIONS

FIGURE 2-1



CONTACT

DASHED WHERE APPROXIMATELY LOCATED, QUERIED WHERE INFERRED.

ARTIFICIAL FILL



PAVEMENT OR GRAVEL



DISTURBED GROUND

<u>OUATERNARY</u>

Qdi RECENT VALLEY FILL
Qi LANDSLIDE

GS STOCHWATTHAMM

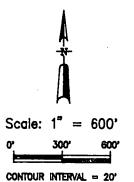
GS STOCHWATTHAMM

GI TANDRIDE

Qy VERDOS ALLUMUM
Qrf ROCKY FLATS ALLUMUM

CRETACEOUS

KOSS ARAPAHOE FORMATION, SANDSTONE
KO ARAPAHOE FORMATION, CLAYSTONE

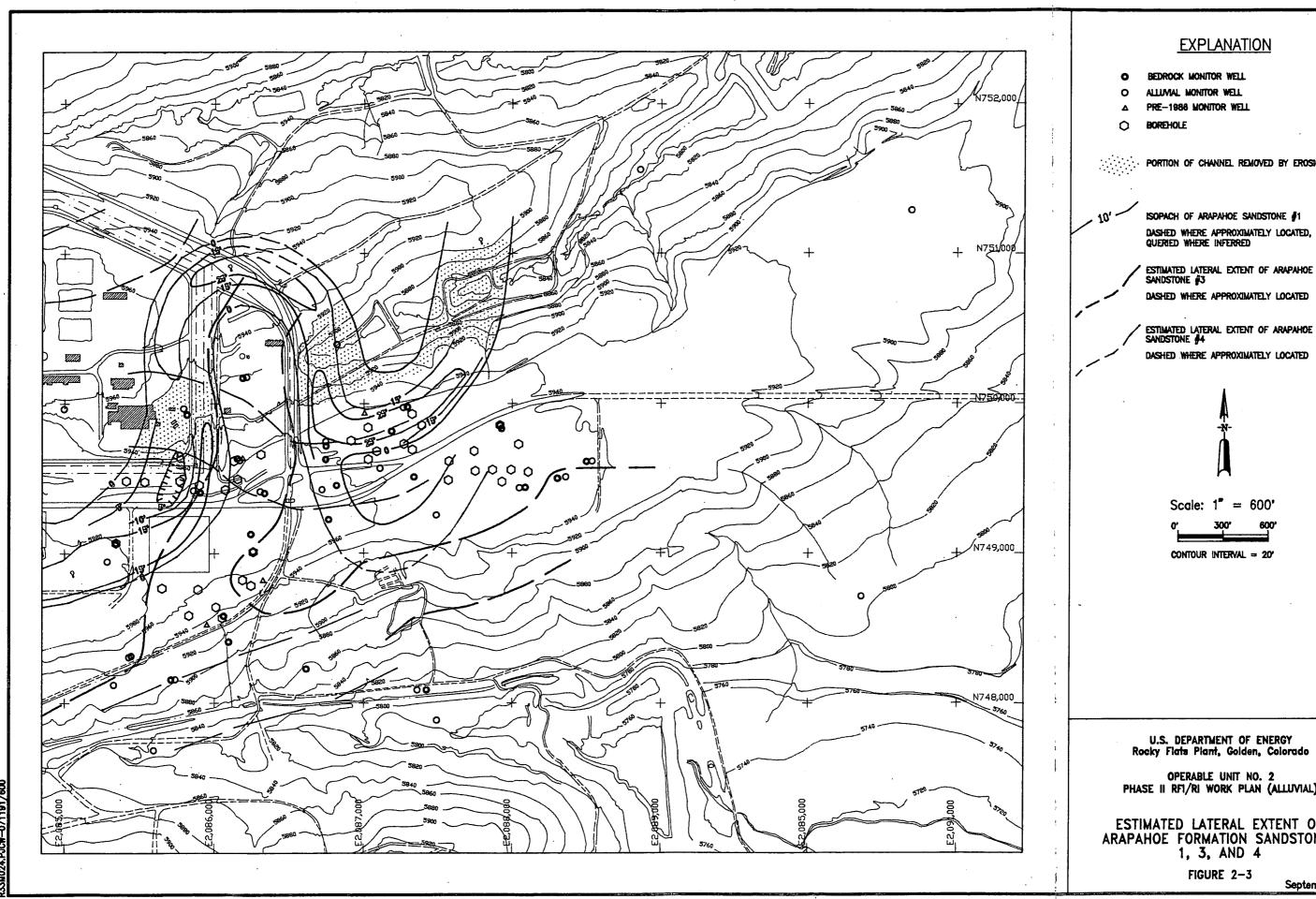


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SURFICIAL GEOLOGY

FIGURE 2-2



PORTION OF CHANNEL REMOVED BY EROSION

ISOPACH OF ARAPAHOE SANDSTONE #1 DASHED WHERE APPROXIMATELY LOCATED, QUERIED WHERE INFERRED

ESTIMATED LATERAL EXTENT OF ARAPAHOE SANDSTONE #3

DASHED WHERE APPROXIMATELY LOCATED



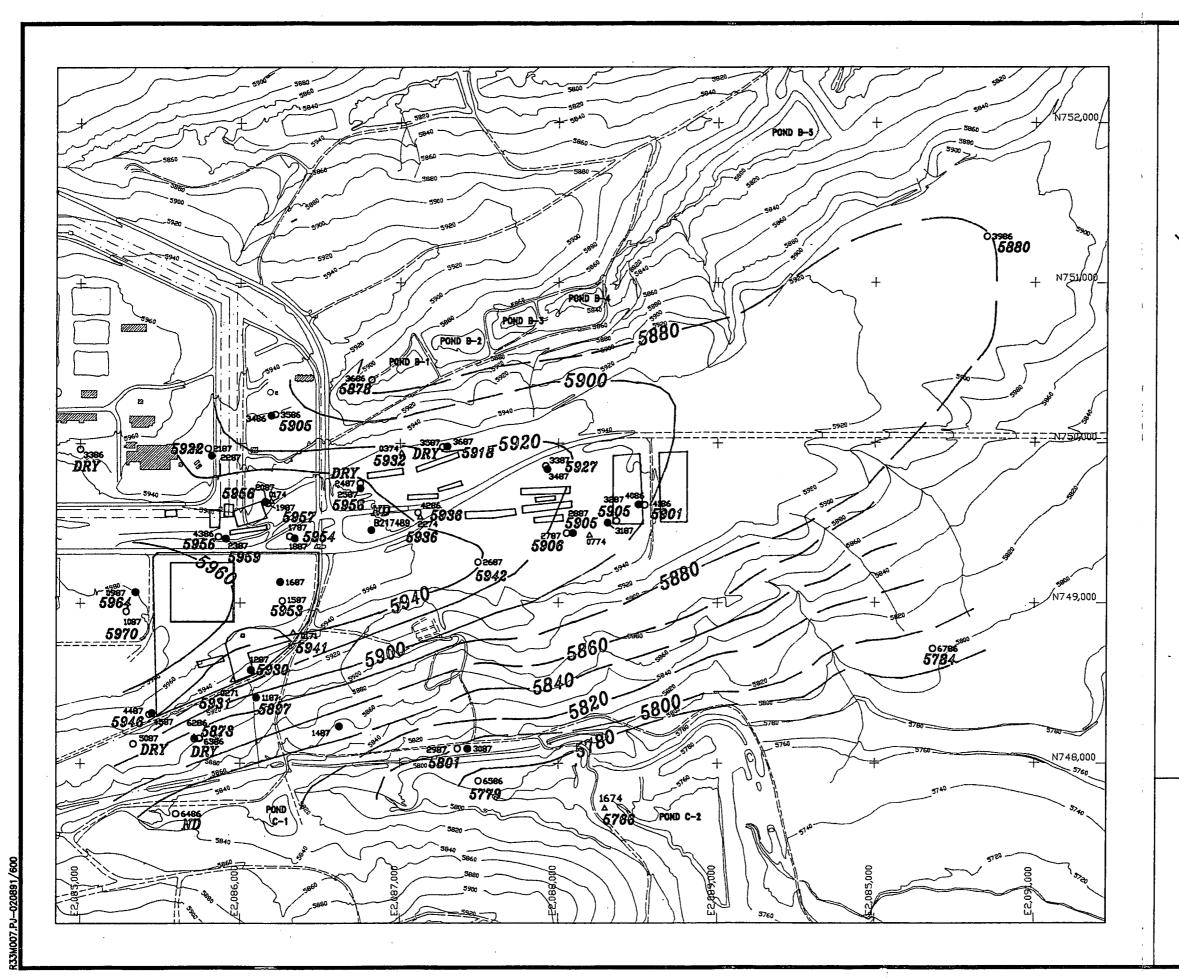
Scale: 1" = 600'

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OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

ESTIMATED LATERAL EXTENT OF ARAPAHOE FORMATION SANDSTONES 1, 3, AND 4

FIGURE 2-3



INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

5798

POTENTIOMETRIC SURFACE ELEVATION (feet above mean sea level)

ALL DATA BASED ON MEASUREMENTS MADE APRIL 4—8, 1988 INCLUSIVE

-5860_

LINE OF EQUAL POTENTIOMETRIC SURFACE ELEVATION (feet above mean sea level)—DASHED WHERE APPROXIMATELY LOCATED

ND

NO DATA

B217489 ● BEDROCK MONITOR WELL

B213789 ○ ALLUMAL MONITOR WELL

0382 △ PRE-1986 MONITOR WELL



Scale: 1" = 600'

0' 300' 600

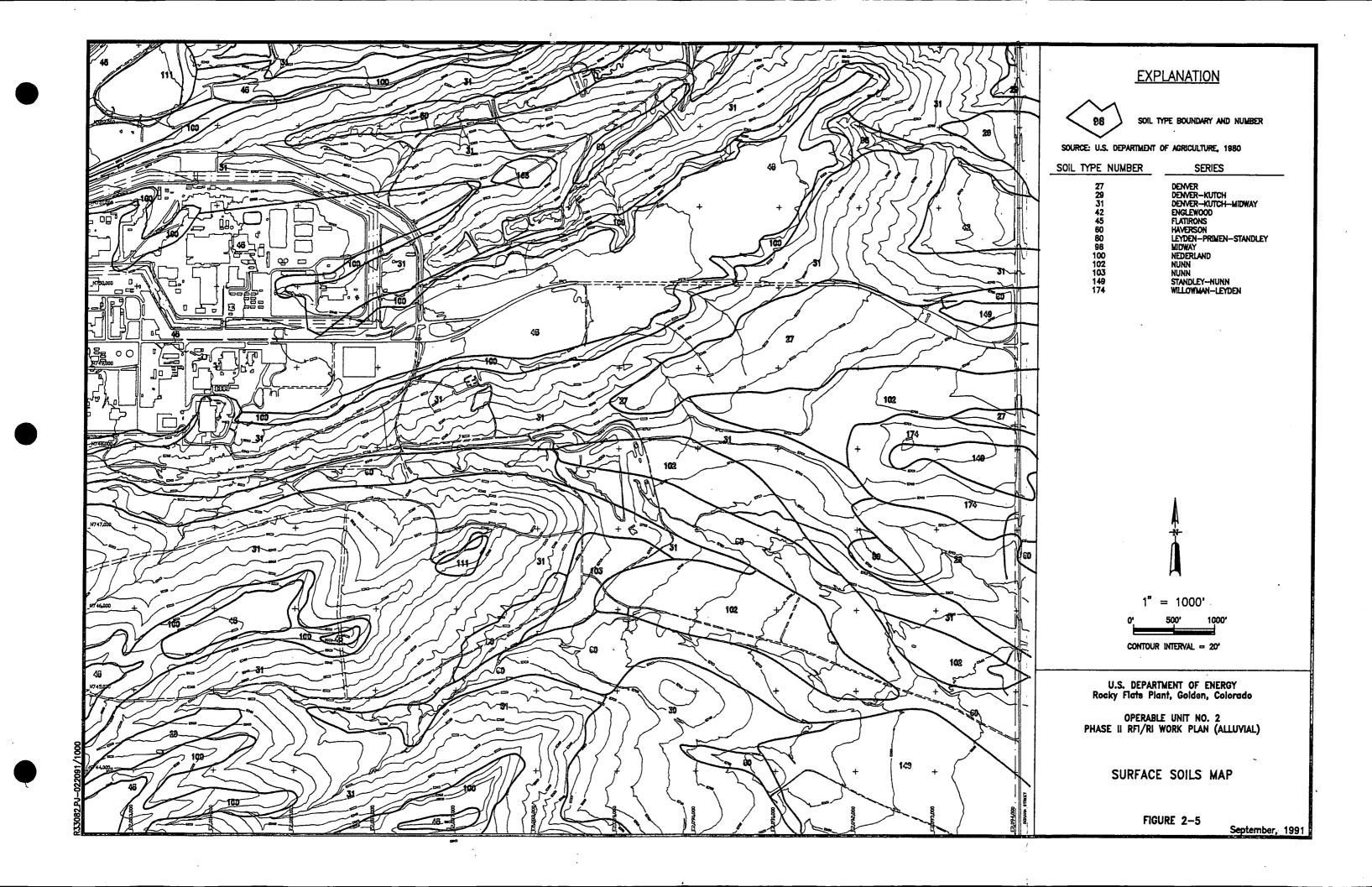
CONTOUR INTERVAL = 20'

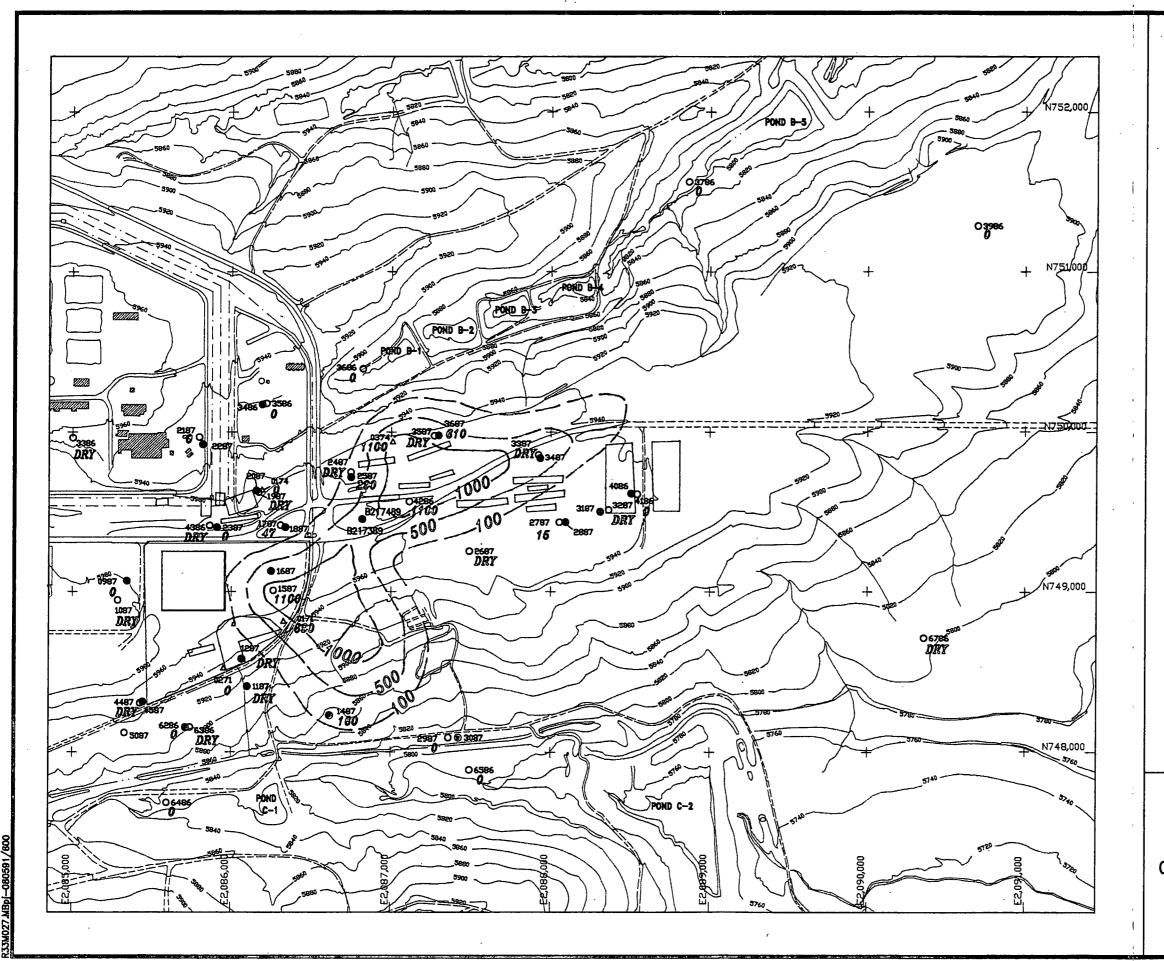
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OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

POTENTIOMETRIC SURFACE OF THE UPPER HYDROSTRATIGRAPHIC GROUND-WATER FLOW SYSTEM

FIGURE 2-4





INDMDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

-500 سر

LINE OF EQUAL CCL4 CONCENTRATION (µg/1)
DASHED WHERE APPROXIMATELY LOCATED

280

CCI 4 CONCENTRATION (49/1)

2587 ● BEDROCK MONITOR WELL

3789 O ALLUMAL MONITOR WELL

0382 △ PRE-1986 MONITOR WELL



Scale: 1" = 600'

CONTOUR INTERVAL = 20°

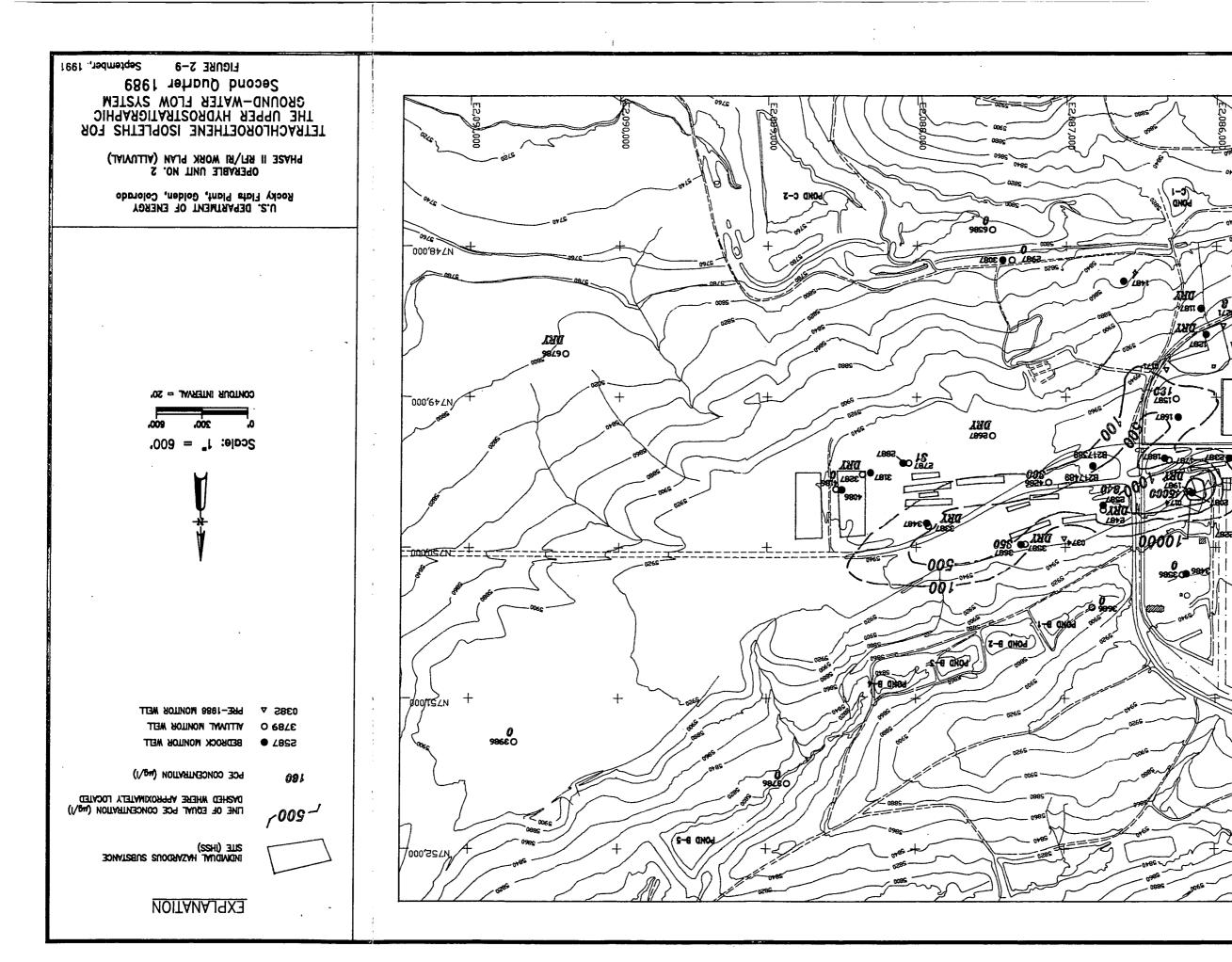
300, 600,

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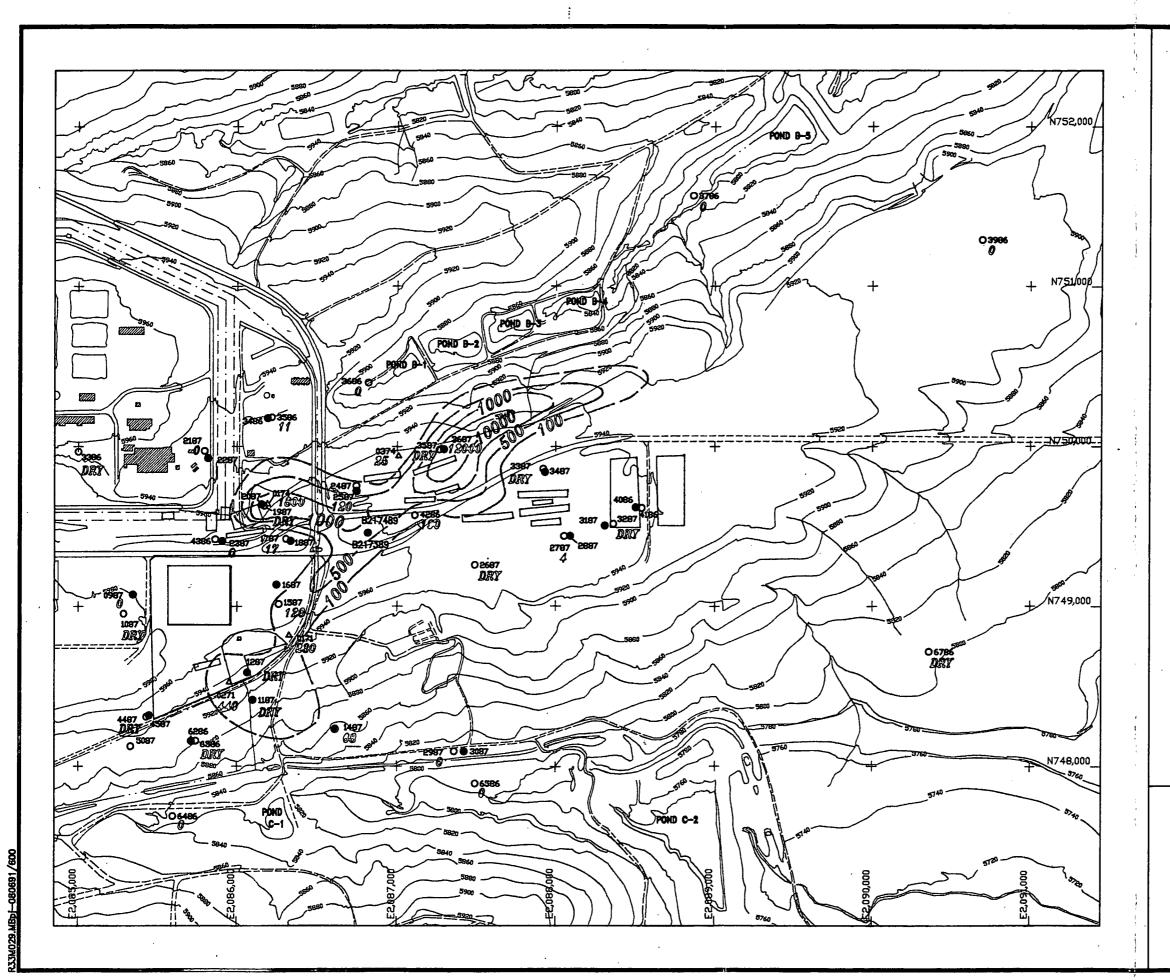
OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

CARBON TETRACHLORIDE ISOPLETHS FOR THE UPPER HYDROSTRATIGRAPHIC GROUND-WATER FLOW SYSTEM Second Quarter 1989

FIGURE 2-8



ana



INDMIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

-500

LINE OF EQUAL TCE CONCENTRATION (µg/1)
DASHED WHERE APPROXIMATELY LOCATED

120

TCE CONCENTRATION (µg/1)

2587 ● BEDROCK MONITOR WELL
3789 ○ ALLUVAL MONITOR WELL
0382 △ PRE-1986 MONITOR WELL

Scale: 1" = 600'

0° 300° 600

CONTOUR INTERVAL = 20°

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PHASE II RFI/RI WORK PLAN (ALLUVIAL)

TRICHLOROETHENE ISOPLETHS FOR THE UPPER HYDROSTRATIGRAPHIC GROUND-WATER FLOW SYSTEM Second Quarter 1989

FIGURE 2-10

SURFACE WATER MONITORING STATION SW-25

SED-11 SEDIMENT SAMPLING STATION

Scale: 1" = 600'
or 300' 600'

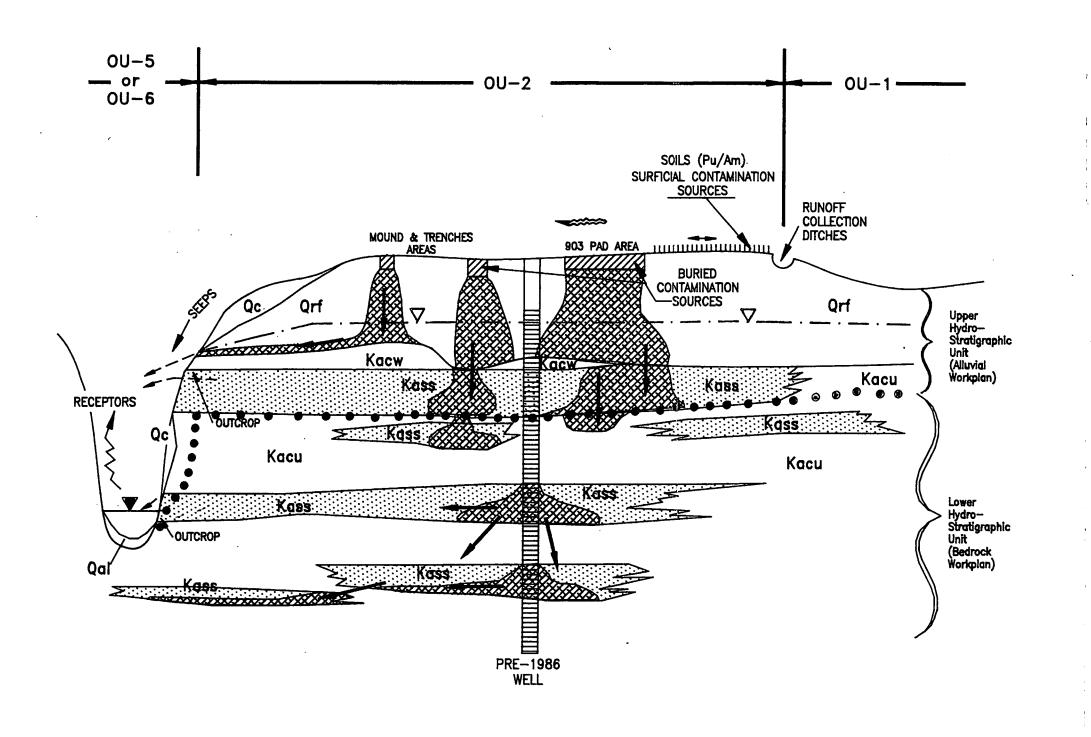
CONTOUR INTERVAL = 20°

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PHASE II RFI/RI WORK PLAN (ALLUVIAL)

SURFACE WATER AND SEDIMENT MONITORING STATIONS

FIGURE 2-11



Contact Between Rocky Flats
 Alluvium and Bedrock (unconformity)

Boundary Between Upper & Lower
Hydrostratigraphic Unit

Contamination Plume (potential)

— — Volatization

Receptor

Groundwater Pathway (potential)

Storm Runoff Pathway

Wind Blown Pathway

Stream Surface

CRETACEOUS BEDROCK UNITS

Kass Sandstone Channels

Kacu Unweathered Claystone/Siltstone
Kacw Weathered Claystone/Siltstone

QUATERNARY ALLUMAL UNITS

Qrf Rocky Flats Alluvium
Qc Colluvium Deposits
Qal Stream Bed Deposits

SCHEMATIC CROSS-SECTIONAL VIEW

NOT TO SCALE

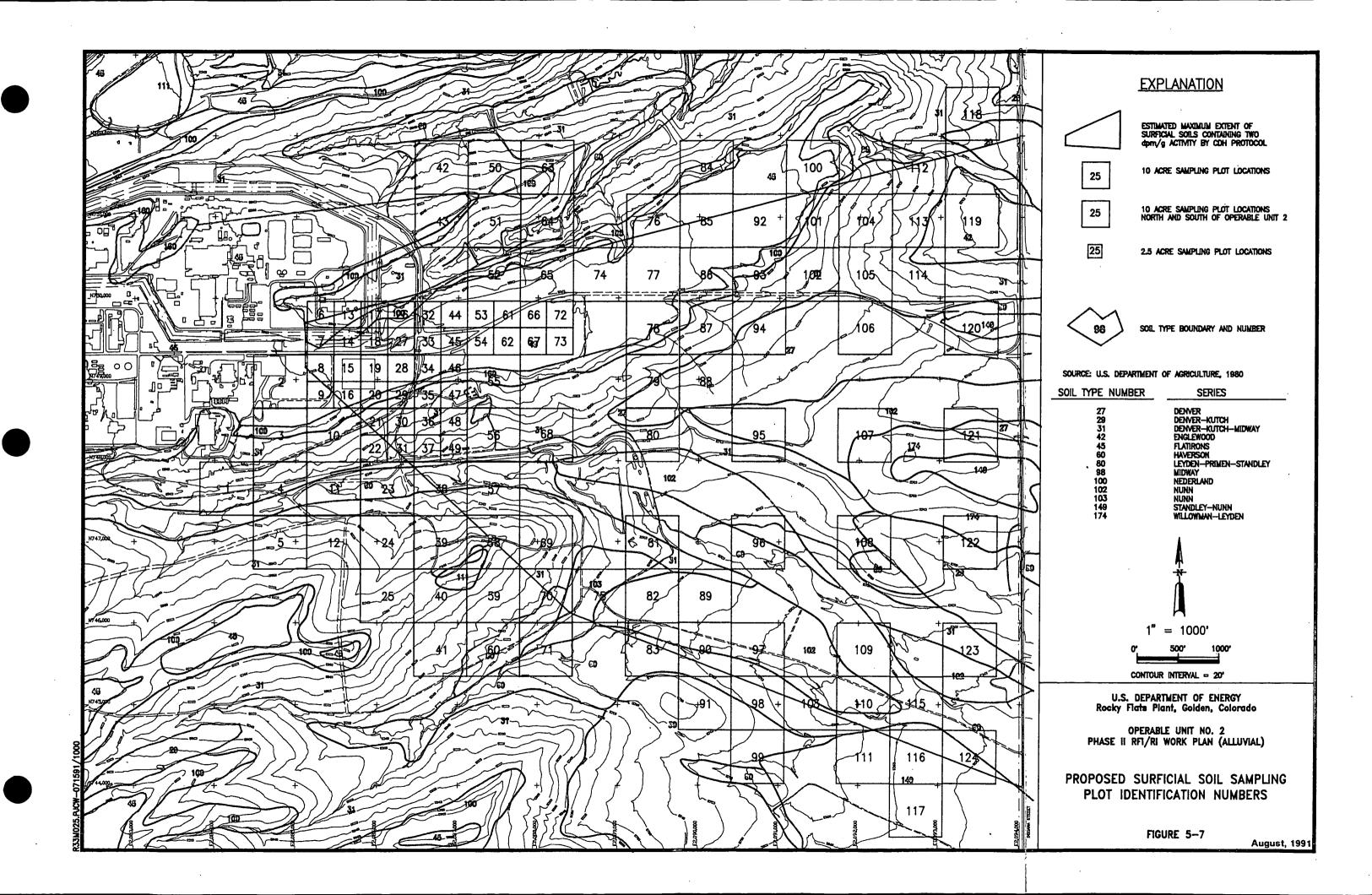
U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

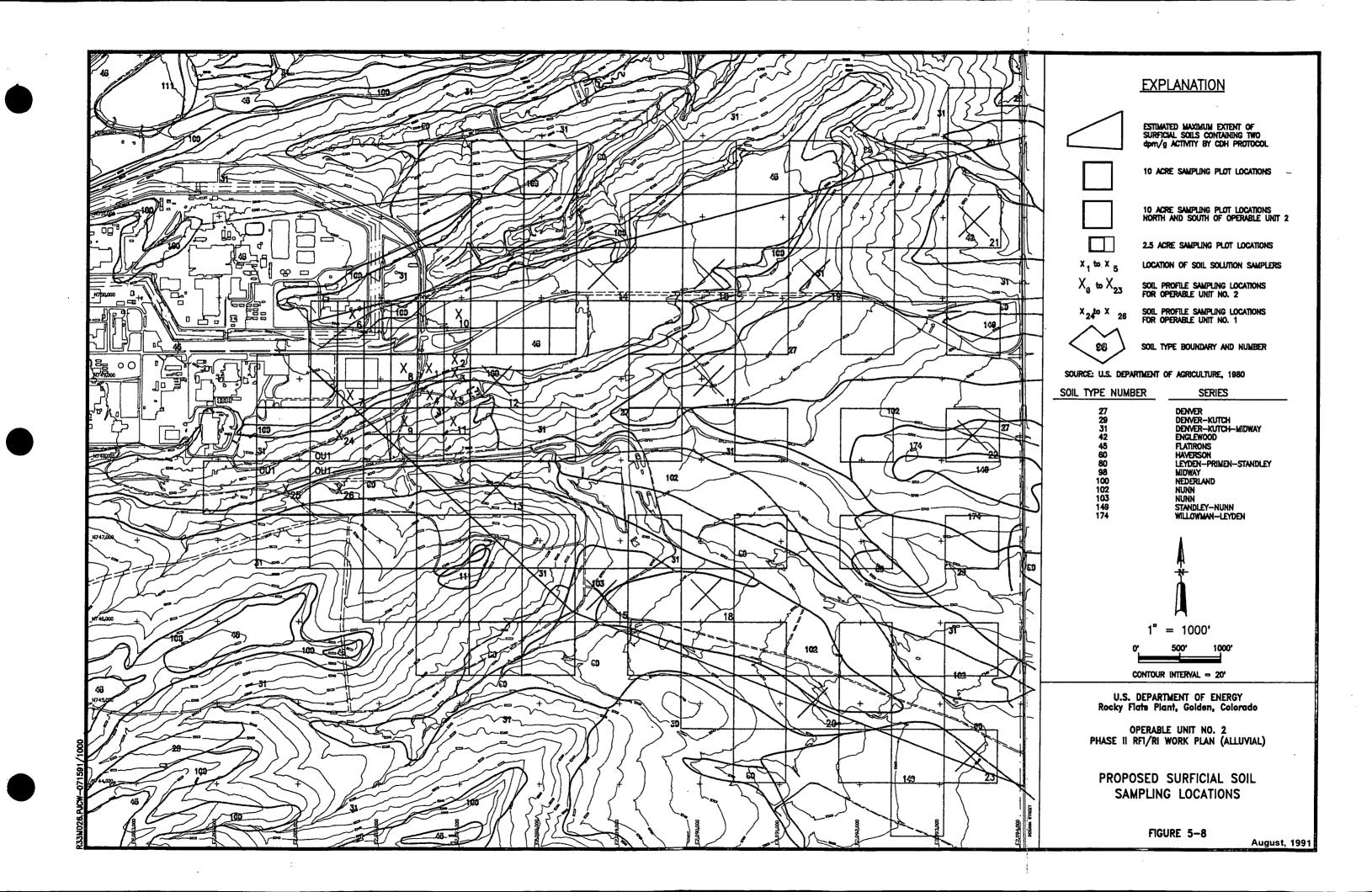
OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

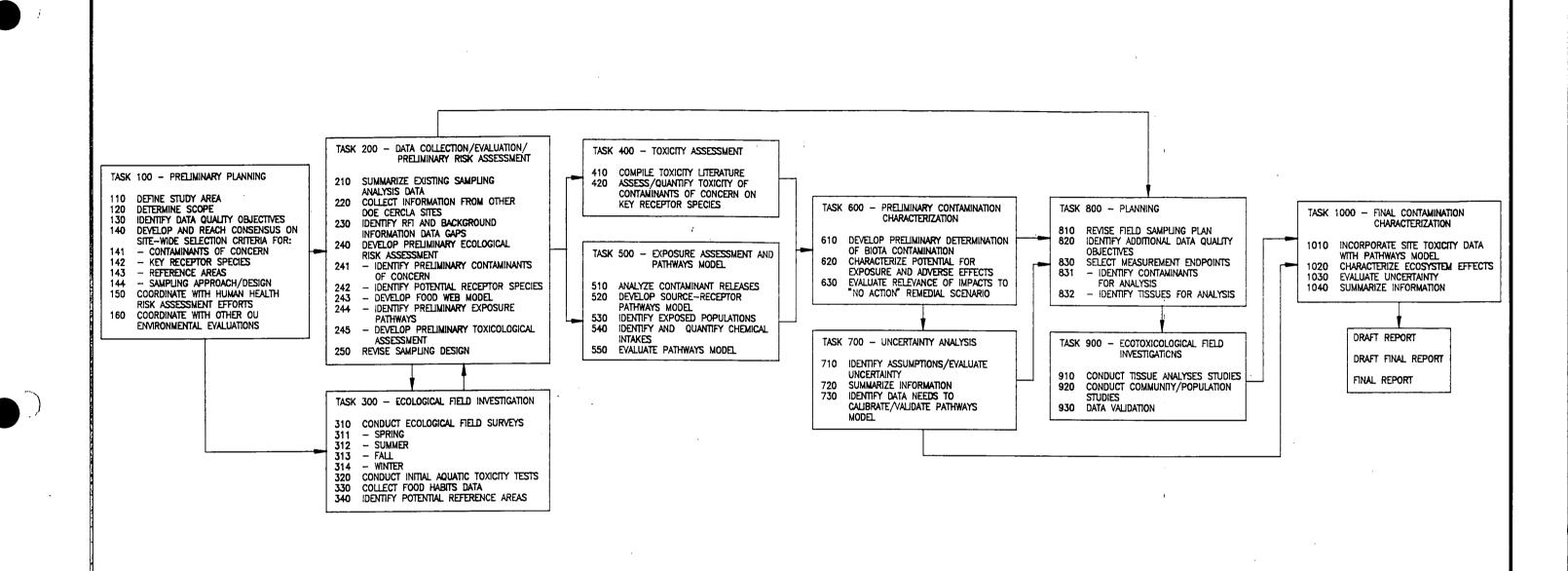
SITE CONCEPTUAL MODEL

FIGURE 2-14 September, 1991

R33055A.PJ-020691







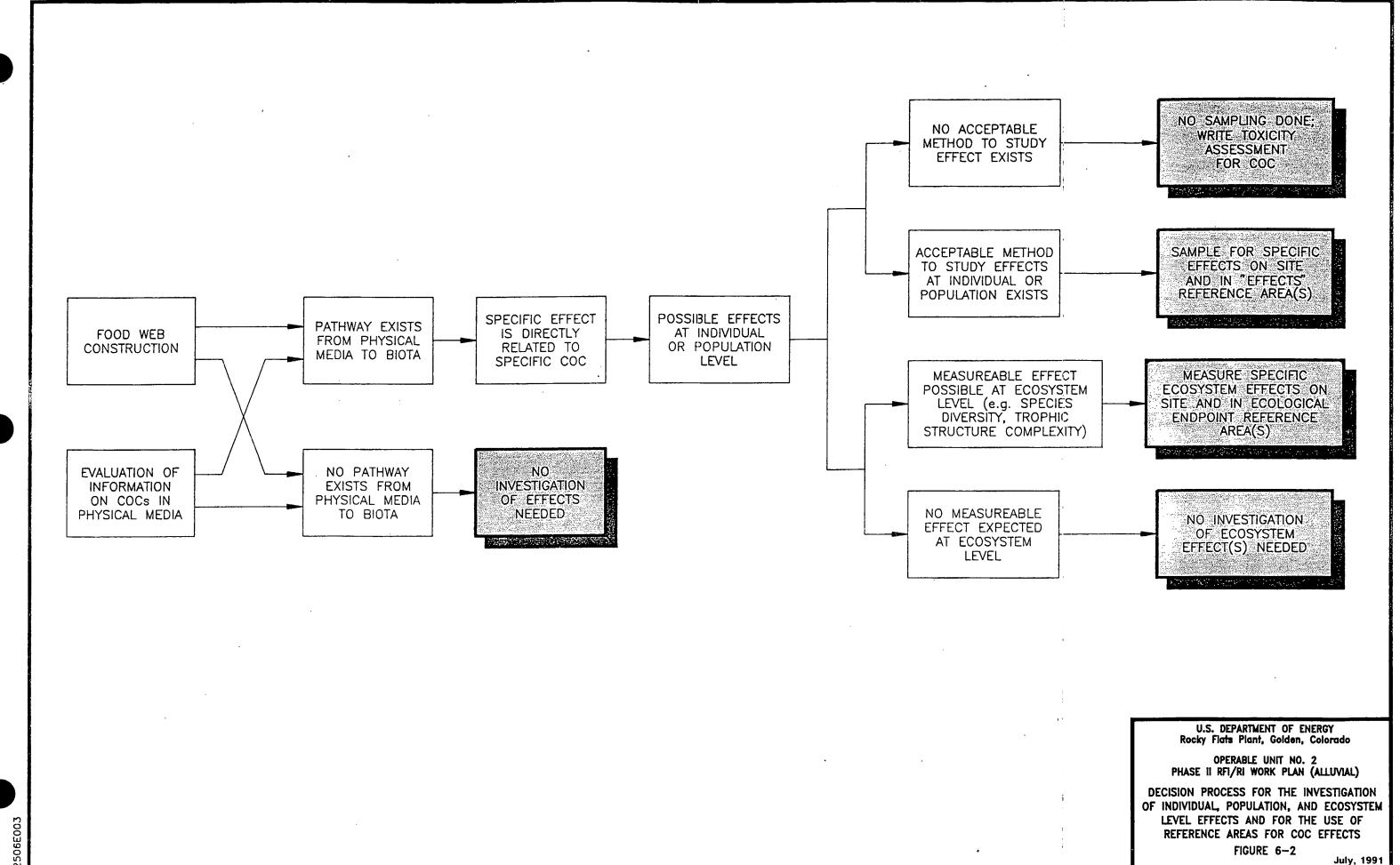
U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

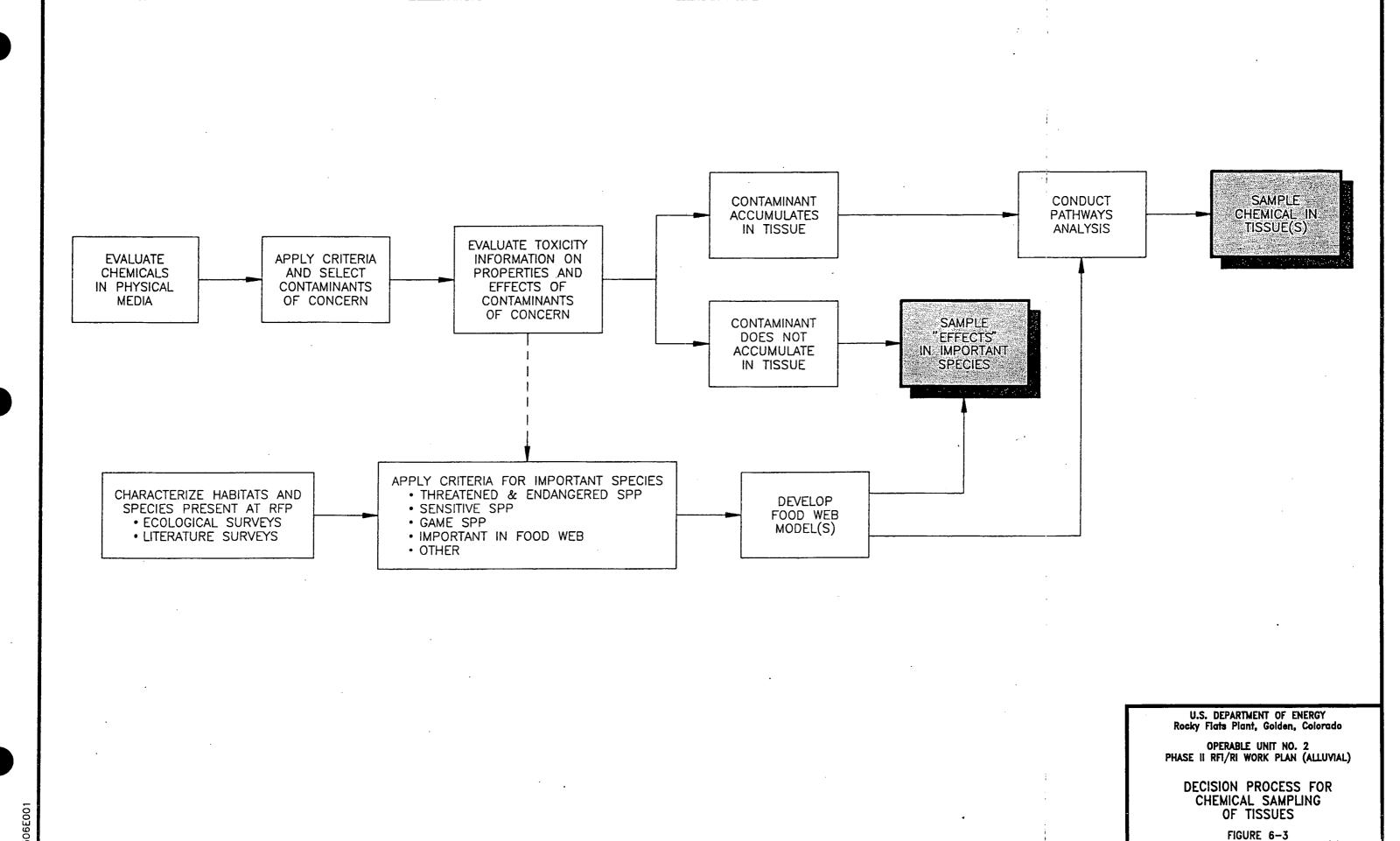
OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

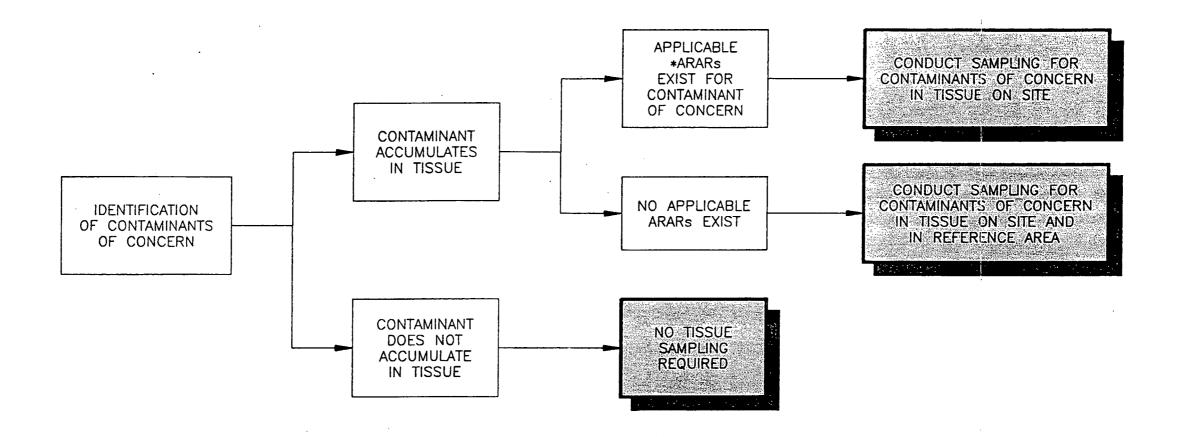
FLOW DIAGRAM:
INTERRELATIONSHIPS BETWEEN TASKS
SITES

FIGURE 6-1

July, 1991







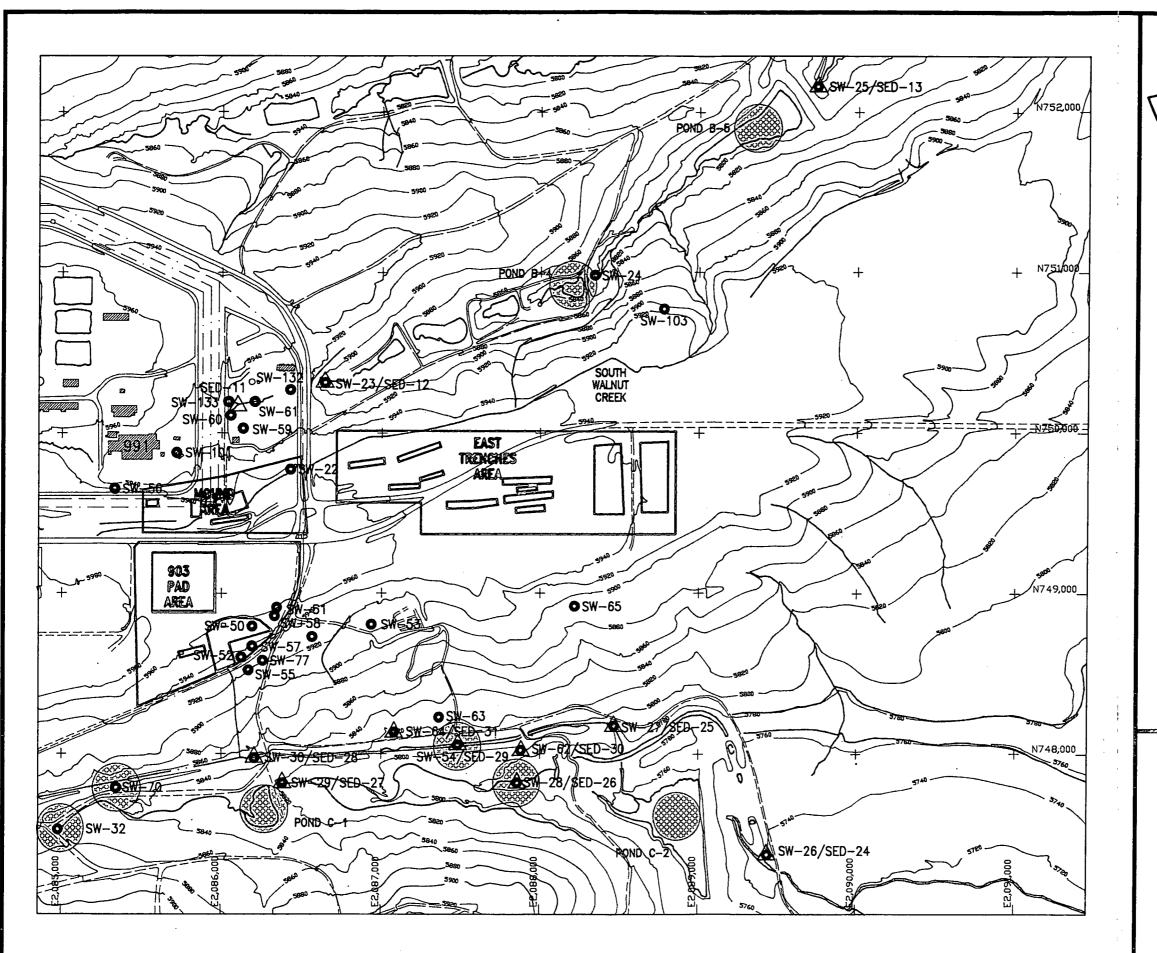
* ARARS MAY NOT BE APPLICABLE IF THEY ARE BASED ON SPECIES THAT DO NOT EXIST ON SITE (e.g., TROUT), ARE BASED ON BIOTA PATHWAYS TO HUMANS, OR IF THEY ARE BELOW BACKGROUND FOR THE REGION (e.g., SOME METALS).

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OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

DECISION PROCESS ON USE OF REFERENCE AREAS FOR CONTAMINANTS IN TISSUES

FIGURE 6-4



EXPLANATION

INDMIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)



SW-23 SURFACE WATER MONITORING STATION



 \triangle SED-13 SEDIMENT MONITORING STATION

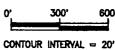


SAMPLE LOCATIONS FOR AQUATIC BIOTA

____ DIRT ROAD



Scale: 1" = 600'



U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

LOCATION MAP OF THE INDIVIDUAL HAZARDOUS SUBSTANCE SITES AND AQUATIC SAMPLING LOCATIONS

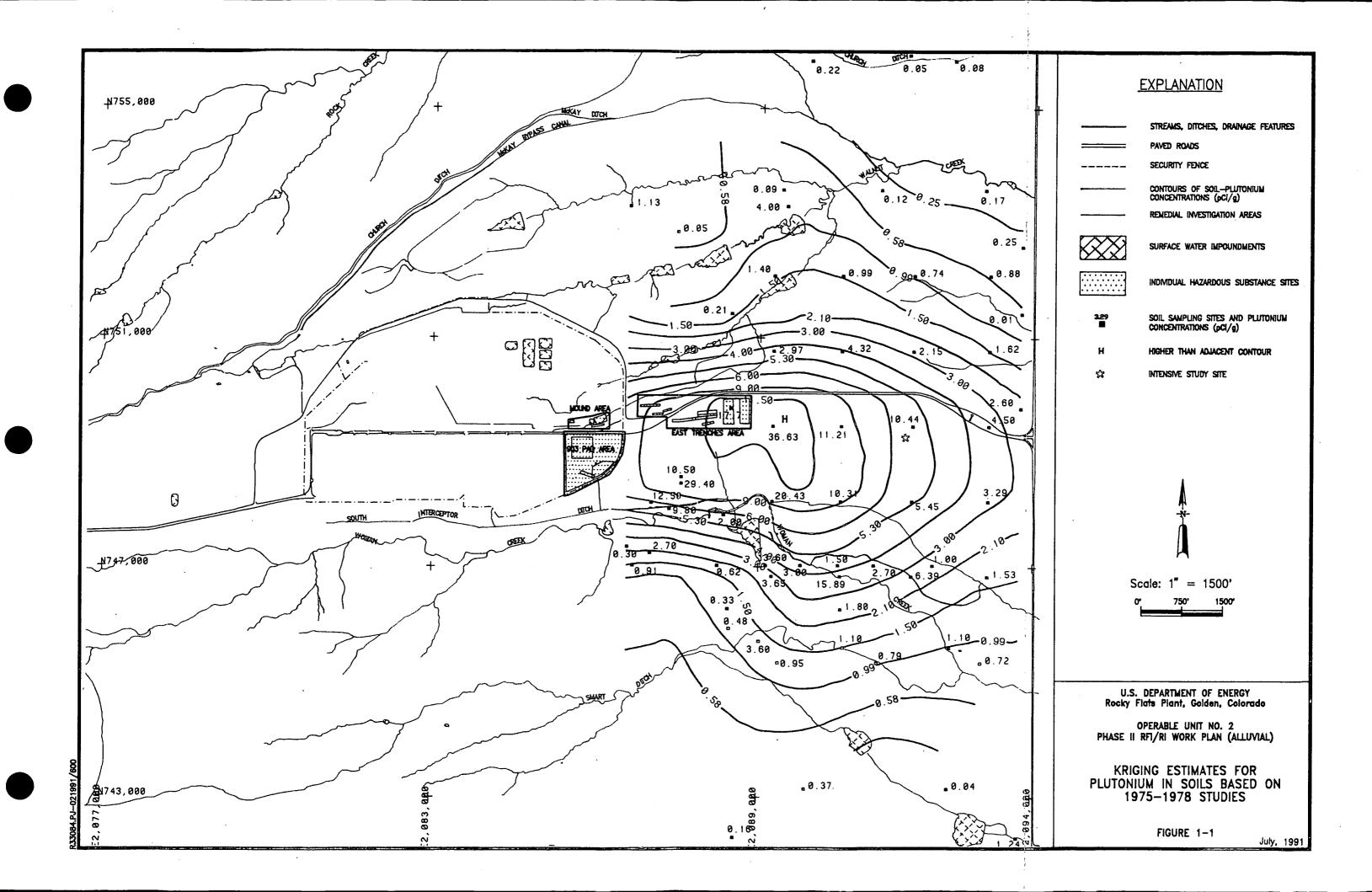
FIGURE 6-6

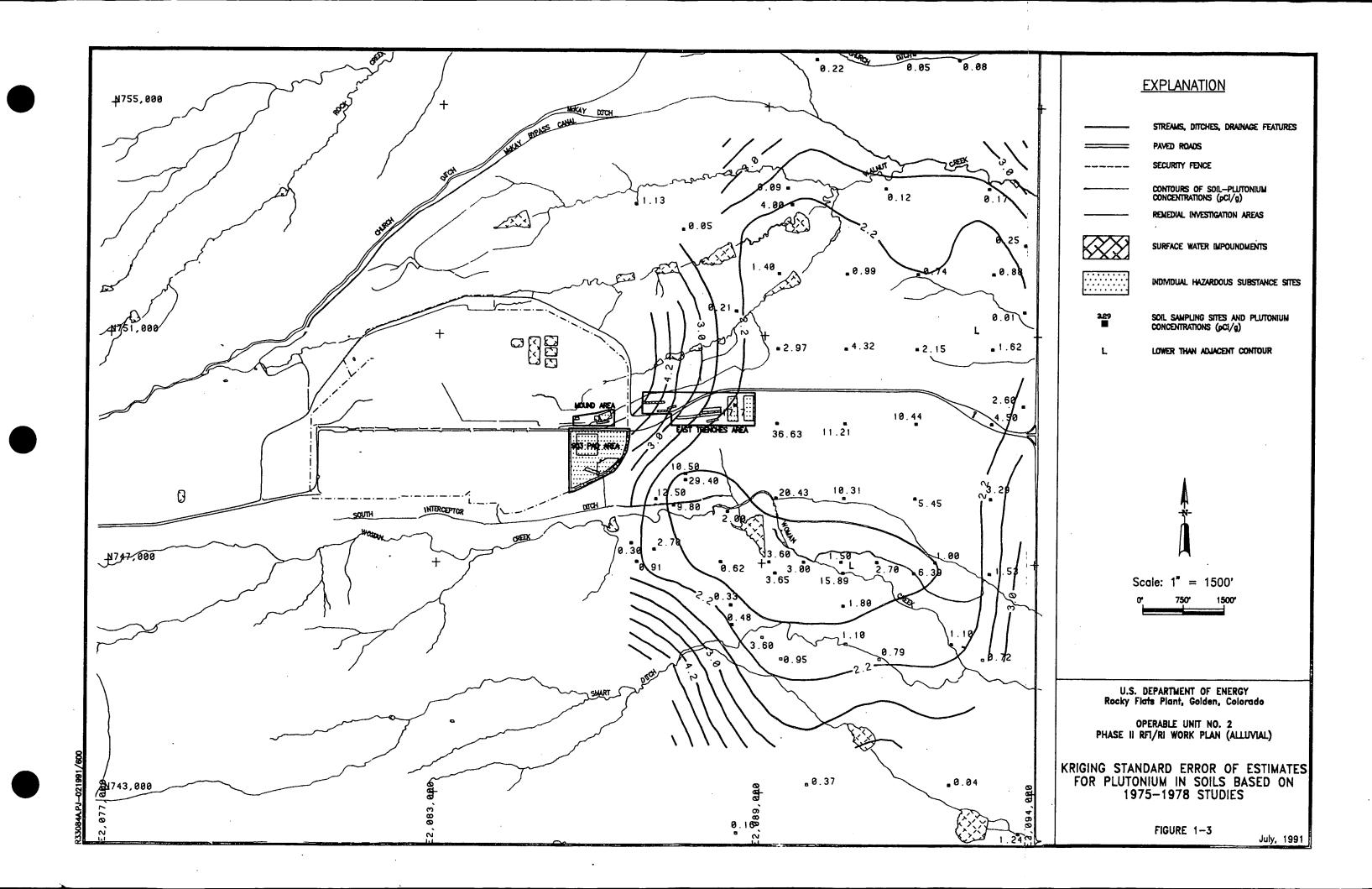
U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

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PHASE II RFI/RI WORK PLAN (ALLUVIAL)

ENVIRONMENTAL EVALUATION ACTIVITY SCHEDULE

FIGURE 6-7





EXPLANATION INDMIDUAL HAZARDOUS SUBSTANCE SITES CONTOURS OF SOIL—AMERICIUM CONCENTRATIONS (pci/g) EAST TRENCHES AREA IN SITU MEASUREMENT SITES AND AMERICUM-241 CONCENTRATIONS (pCI/g) N750,000 HIGHER THAN ADJACENT CONTOUR 1.4 1.8 2.2 2.2 1.6 1.7 1.1 X X _0.9 _1.8 LOWER THAN ADJACENT CONTOUR LOCATION WHERE MEASUREMENTS WERE LESS THAN 0.9 pCI/g MOUND AREA 1.5 5.2 4.8 31 NOTE: AMERICIUM CONCENTRATIONS WERE DERIVED FROM IN SITU RADIOLOGICAL SURVEY MEASUREMENTS, (EG&G/EM, 1990). 10.0 6.0 10.0 _7.8 20.0 18.0 13.0 8.1 6.1 6.8 8.3 6.8 .4.2 .1.2 X 19.0 19.0 19.0 27.0 .8.3/ **3**4.0 **1**8.0 .0.8 28.0/ 4.0 10.0 14.0 .1.2 16.0 13.0 **_3.4** 4.2 a4.8 .12.0 .8.1\ _a5.5 _a4.9 _a4.5 "3.6 "3.7 "3.1 "3.4 _12.0 <u>_</u>9.0 .5.7 .3.8 .1.5 .2.7 .2.9 .2.8 . 2.4 2.0 0.9 U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado .5.2 .4.9 .4.7 .3.3**/** al.1 a2.5 a2.3 a2.4 a1.6 a0.5 a1.2 a1.6 OPERABLE UNIT NO. 2 PHASE II RFI/RI WORK PLAN (ALLUVIAL) 1.9 _2.9 _3.0 _2.8 8.0 KRIGING ESTIMATES FOR AMERICIUM IN SOILS BASED ON 1990 STUDIES FIGURE 1-4 July, 1991

EAST TRENCHES AREA N750,000 1,4 1.8 2.2 2.2 1.6 1.7 1.1 X .0.9 _.1.8 MOUND AREA 1.5 .5.2 .4.8 .31 .0.9 7.2 14.0 5.0 5.7 10.0 6.0 10.0 7.8 **√**1.9 **1**0.0 **2**0.0 **1**8.0 **1**3.0 **8**.1 **6**.1 **6**.8 **8**.3 **6**.8 **4**.5 _32.0 _19.0 _19.0 _19.0 _11.0 _4.2 _1/2 .0.9 .0.9 .1.1 27.0 8.3 34.0 18.0 19.0 18.0 **1**0.8 **x** 2.9 3.7 **√**37.0 **2**8.0 **1**4.0 **7.6 4.0 10.0 14.0 12 X .**5.7 **.**5.7 **.**3.5 _23.5 _16.0 _13.0 _2.0 _5.8 _6.4 _7.8 _5.3 _3.1 _4.2 _4.8 _3.4 _2.2/ _24.0 _18.0 _16.0 _12.0 _8.1 _5.5 _4.9 _4.5 _3.6 _3.7 _3.1 _3.4 _2.3 a 15.0 a 11.0 a 12.0 a 9.0 a 6.1 a 5.7 a 3.8 a 1.5 a 2.7 a 2.9 a 2.8 a 3.1 a 2.4 a 2\0 .4.2 .5.3 .4.4 .5.2 .4.9 .4.7 .3.3 .1.1 .2.5 .2.3 .2.4

EXPLANATION

INDMIDUAL HAZARDOUS SUBSTANCE SITES

CONTOURS OF SOIL—AMERICIUM CONCENTRATIONS (pCi/g)

IN SITU MEASUREMENT SITES AND AMERICIUM-241 CONCENTRATIONS (pCI/g)

LOWER THAN ADJACENT CONTOUR

LOCATION WHERE MEASUREMENTS WERE LESS THAN 0.9 pci/g

NOTE: AMERICIUM CONCENTRATIONS
WERE DERIVED FROM IN SITU
RADIOLOGICAL SURVEY MEASUREMENTS, (EG&G/EM, 1990).

Scale: 1" = 300'

U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

KRIGING STANDARD OF ERROR ESTIMATES FOR AMERICIUM IN SOILS BASED ON 1990 STUDIES

FIGURE 1-5

EXPLANATION INDMIDUAL HAZARDOUS SUBSTANCE SITES CONTOURS OF SOIL-PLUTONIUM CONCENTRATIONS (pCi/g) EAST TRENCHES AREA IN SITU MEASUREMENT SITES AND PLUTONIUM CONCENTRATIONS (pCI/g) HIGHER THAN ADJACENT CONTOUR N750,000 8.7 . 11.2 . 13.7 . 13.7 . 9.9 . 10.5 . 6.8 X LOWER THAN ADJACENT CONTOUR LOCATION WHERE MEASUREMENTS WERE LESS THAN 0.9 pCI/g 14.3 22.4 14.9 MOUND AREA 44.8 87.2 81.1 35.5 62.3 37.3 62.3 48.5 373 66.3 PLUTONIUM CONCENTRATIONS WERE DERIVED FROM AMERICUM CONCENTRATIONS—WHICH IN TURN WERE DERIVED FROM IN SITU RADIOLOGICAL MEASUREMENTS (EGAG/EM, 1990). 80.9 \50.4 38.0 42.3 51.7/ 42.3/ 28.0 7.4 145.80 0 199.3 18.3 18.3 18.3 68.5 / 26, 211.8 . 112.1 / 118.8 . 1\2.1 . 4.9 X ∕8.0 <u> 35.5 35.5 2</u>.8 <u> 14.9</u> 12.4 30.1 39.8 48.5 33.0 19.3 26.1 29.9 21.1 13.7 8.0 U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado **^** 29.2 **2**0.5 6.3 15.5 14.3 14.9 **/** 9.9 3.1 7.4 9.9 OPERABLE UNIT NO. 2 PHASE II RFI/RI WORK PLAN (ALLUVIAL) 10.50 -12.4 18.0 18.6 17.4 16.1 17.4 11.8 X KRIGING ESTIMATES FOR PLUTONIUM IN SOILS BASED ON 1990 STUDIES FIGURE 1-6 July, 1991

EAST TRENCHES AREA N750,000 **_11.2 _13.7 _13.7 _9.9 _10.5 _6.8 .**5.6 **.** 11.2 **..** MOUND AREA 32.3 29.9 **_**5.6 44.8 87.2 31.1 35.5 62.3 37.3 62.3 48.5 37.3 11.8 _62.3 _124.6 _112.1 _80.9 _50.4 _38.0 _42.3 _51.7 _42.3 _28.0 _115/2 _199.3 _118.3 _118.3 _118.3 _68.5 _26.1 _7.4/ 12.4 _5.6 _5.6 _6.8 _4.9 56.9 168.2 51.7 211.8 112 1 118,3 112.1 4.9 _ 18.0 _ 23.0 _ 13.0 _239.5 _174.4 _87.2 _47.3 _24.9 _62.3 _87.2 _7. _35.5 _35.5 _21.8 _14.9 . 186.9 | 146.4 | 99.6 | 80.9 | 12.4 | 36.1 | 39.8 | 48.5 | 33.0 | 19.3 | 26.1 | 29.9 | 21.1 | 13.7 /49.5 _112.1 _99.6 _74.7 _50.4 _34.2 _30.5 _28.0 _22.4 _23.0 _19.3 _21_1 _14.3 _1/.2 _e68.5 _e74.7 **"93.4/** _56.0 _38.0 _35.5 _23.6 √9.3 _16.8 _18.0 _17.4 _19.3 _14.9 _12.4 _5.6 _32.3 _30.5 _29.2 _20.5 _6.3 _15.5 _14.3 _14.9 ■10.5 ■12.4 ■18.0 ■18.6 ■17.4 ■16.1 ■17.4 ✓■11.8

EXPLANATION

INDMIDUAL HAZARDOUS SUBSTANCE SITES

CONTOURS OF SOIL—PLUTONIUM CONCENTRATIONS (pCI/g)

IN SITU MEASUREMENT SITES AND PLUTONIUM CONCENTRATIONS (pci/g)

L LOWER THAN ADJACENT CONTOUR

LOCATION WHERE MEASUREMENTS WERE
LESS THAN 0.9 pCl/g

NOTE: PLUTONIUM CONCENTRATIONS WERE
DERIVED FROM AMERICIUM CONCENTRATIONS—
WHICH IN TURN WERE DERIVED FROM
IN SITU RADIOLOGICAL MEASUREMENTS
(EG&G/EM, 1990).



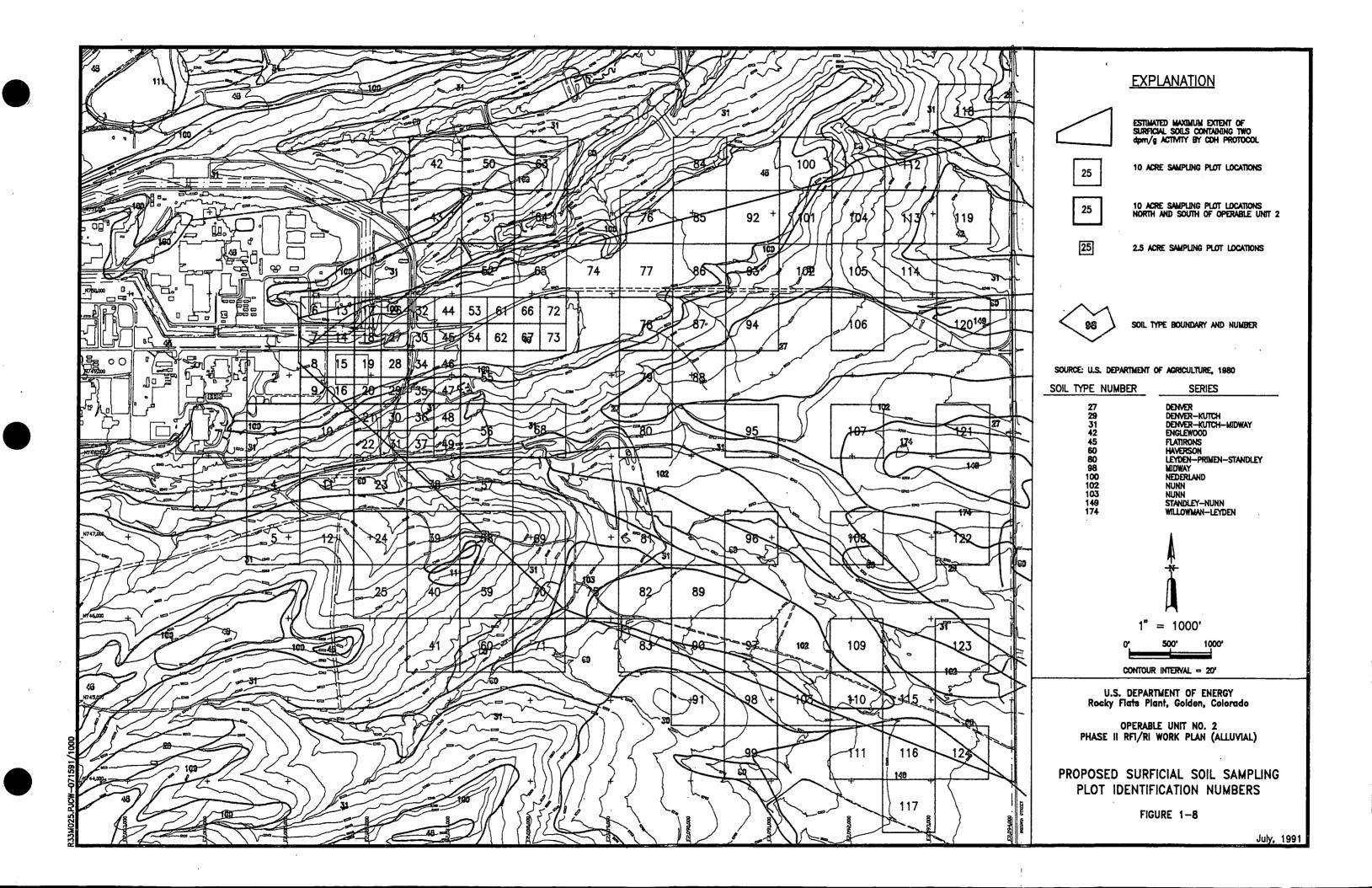
Scale: $1^{\circ} = 300$

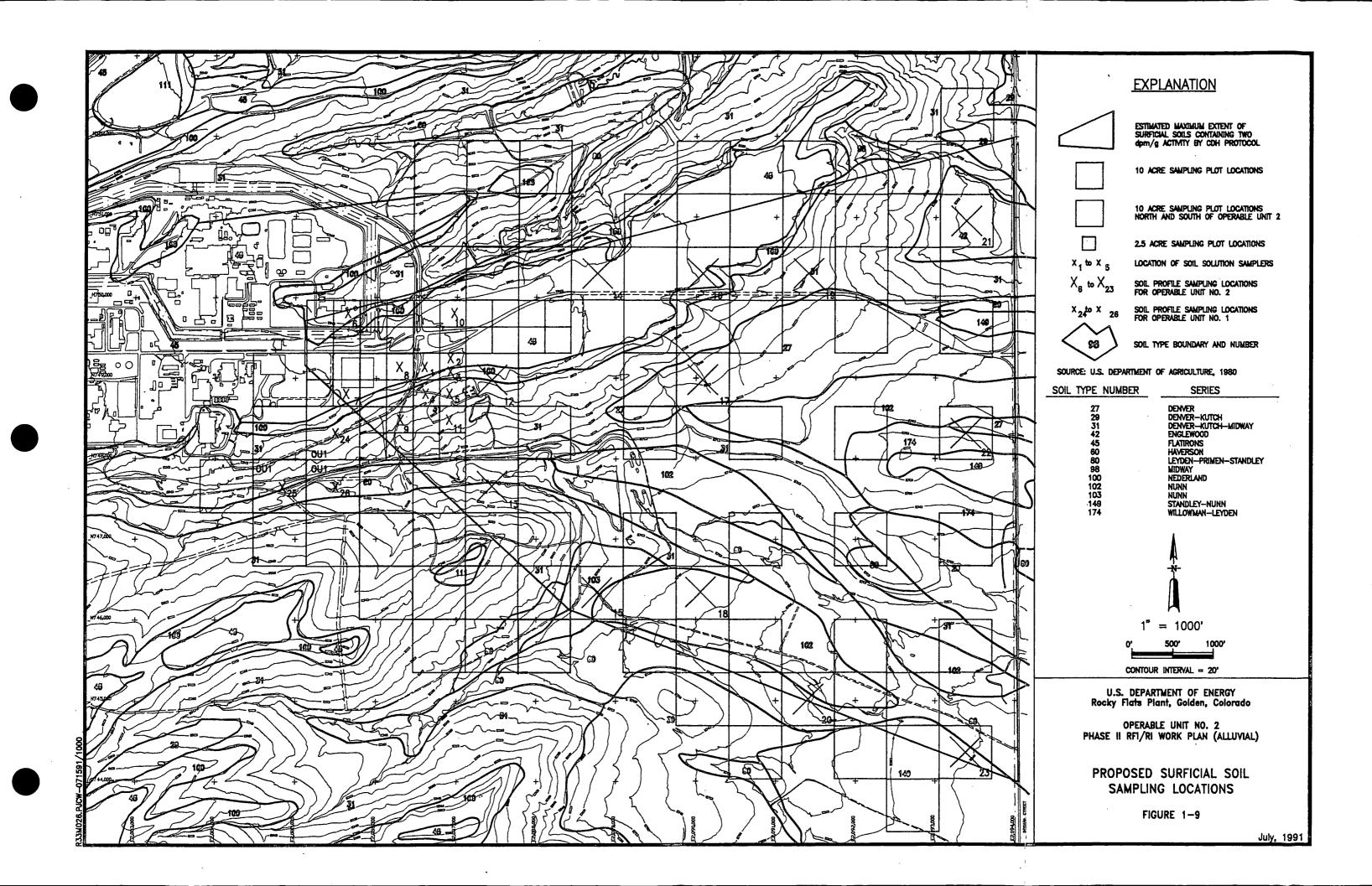
U.S. DEPARTMENT OF ENERGY Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
PHASE II RFI/RI WORK PLAN (ALLUVIAL)

KRIGING STANDARD OF ERROR ESTIMATES FOR PLUTONIUM IN SOILS BASED ON 1990 STUDIES

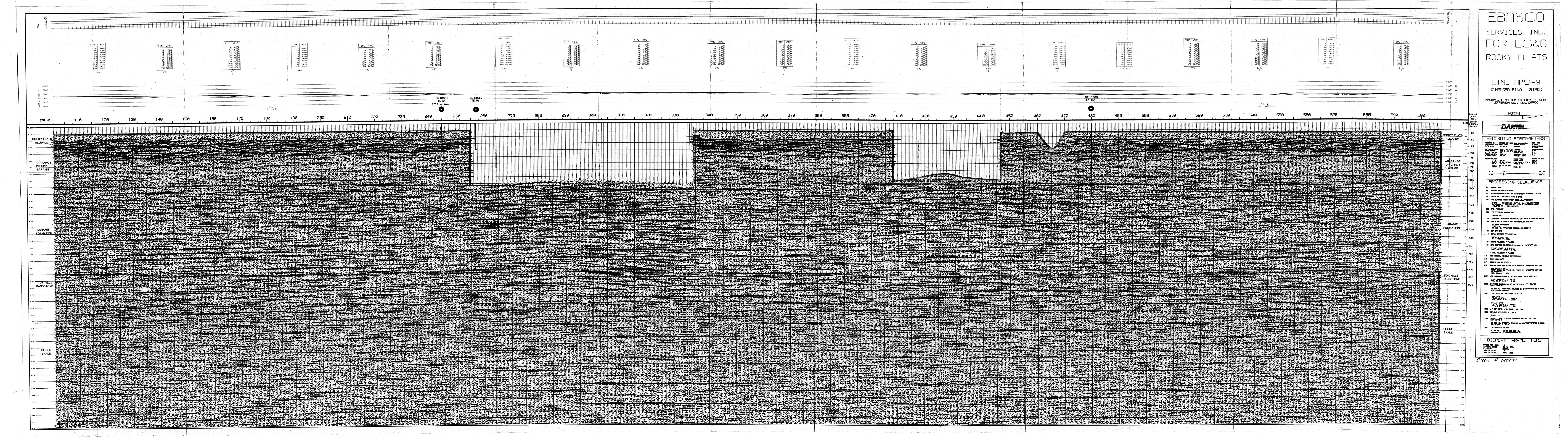
FIGURE 1-7

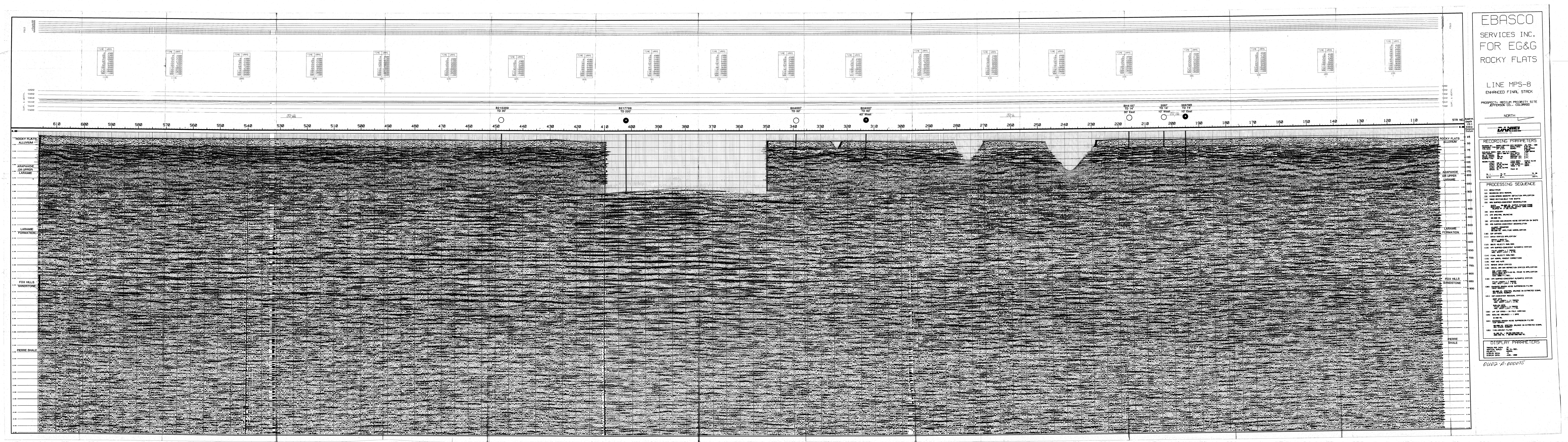


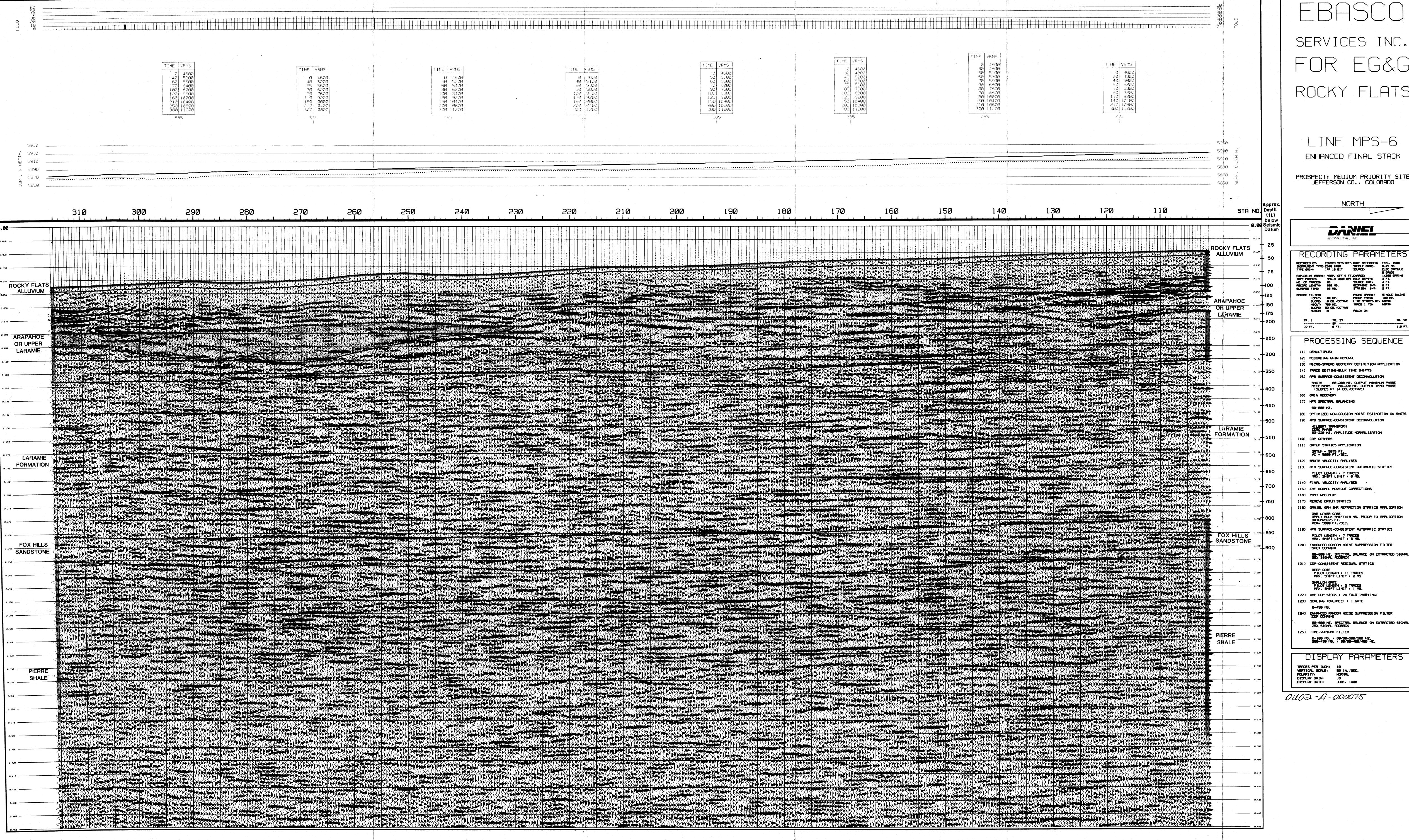


REVIEWED FOR CLASSIFICATION/UCNI
By _____ F. J. Curran U NU
Date _____ /U - 4 - 71

A-0U02-000075





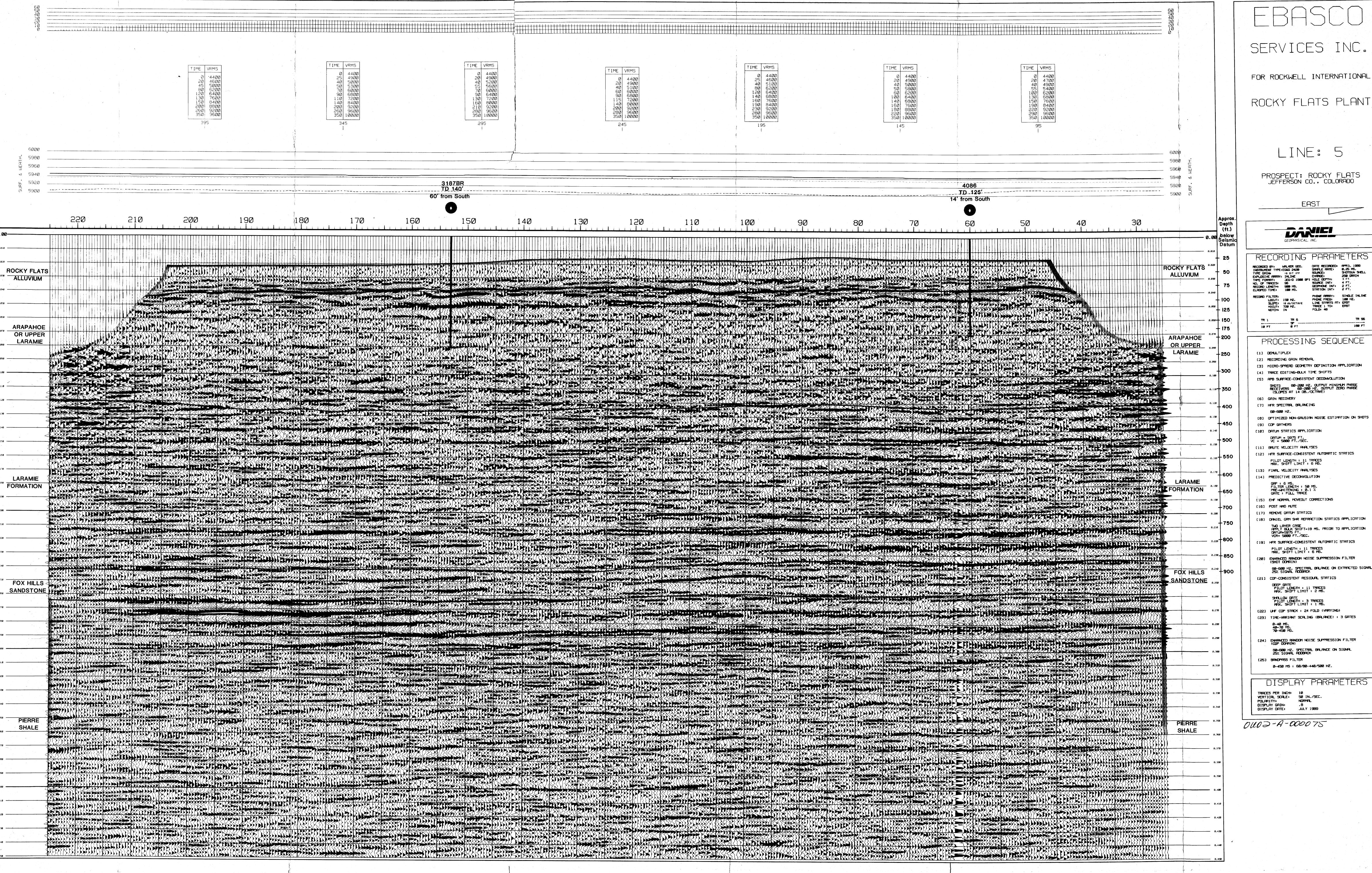


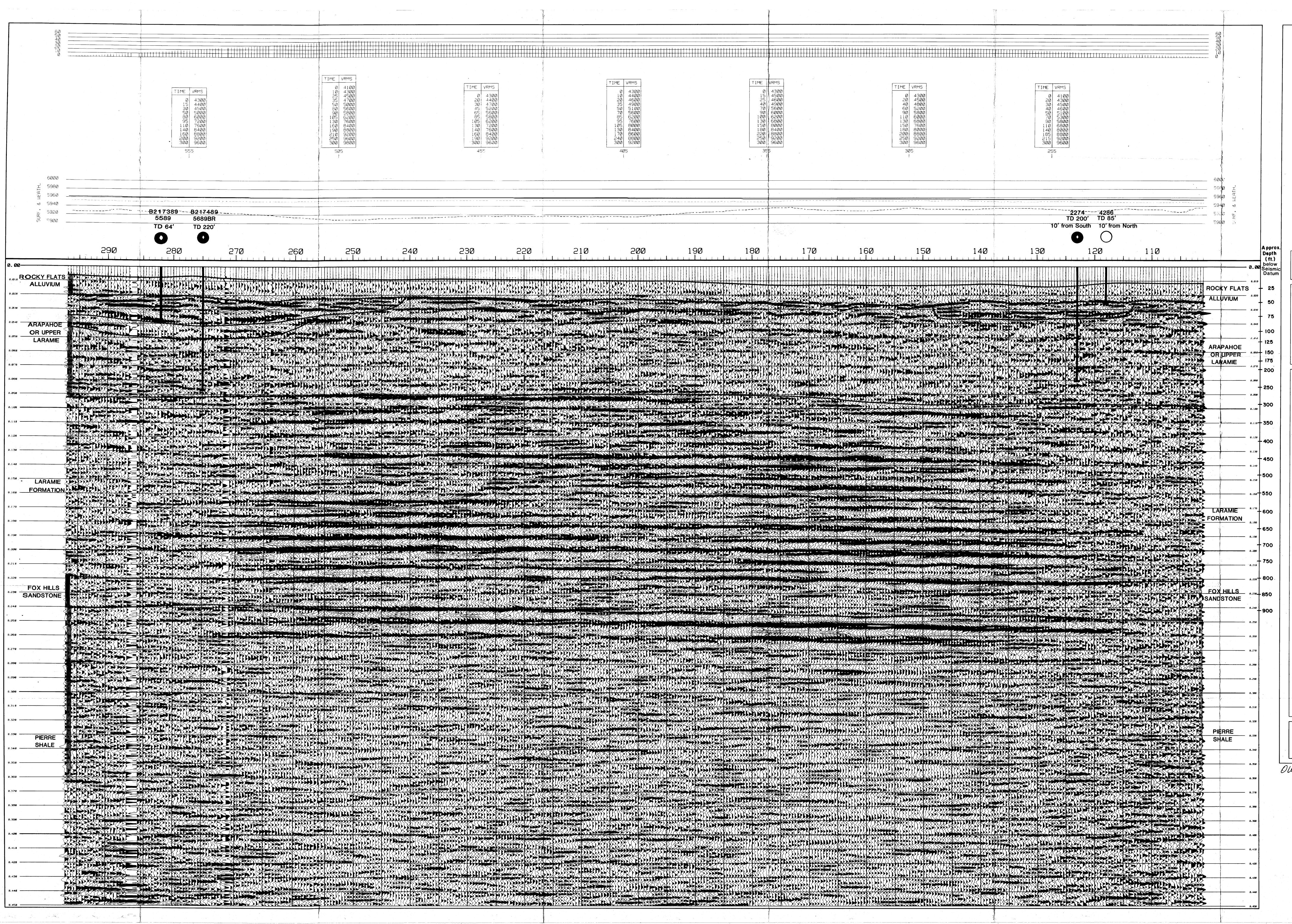
ROCKY FLATS

ENHANCED FINAL STACK

- ONE LAYER CASE
 APPLY BULK SHIFT=18 MS. PRIOR TO APPLICATION
 DATUM-5975 FT.
 VCR= 5000 FT./SEC.

- 69-666 HZ. SPECTRAL BALANCE ON EXTRACTED SIGNAL 25% SIGNAL ROOMS





SERVICES INC.

FOR ROCKWELL INTERNATIONAL

ROCKY FLATS PLANT

LINE: 4

PROSPECT: ROCKY FLATS JEFFERSON CO., COLORADO

DANIEL

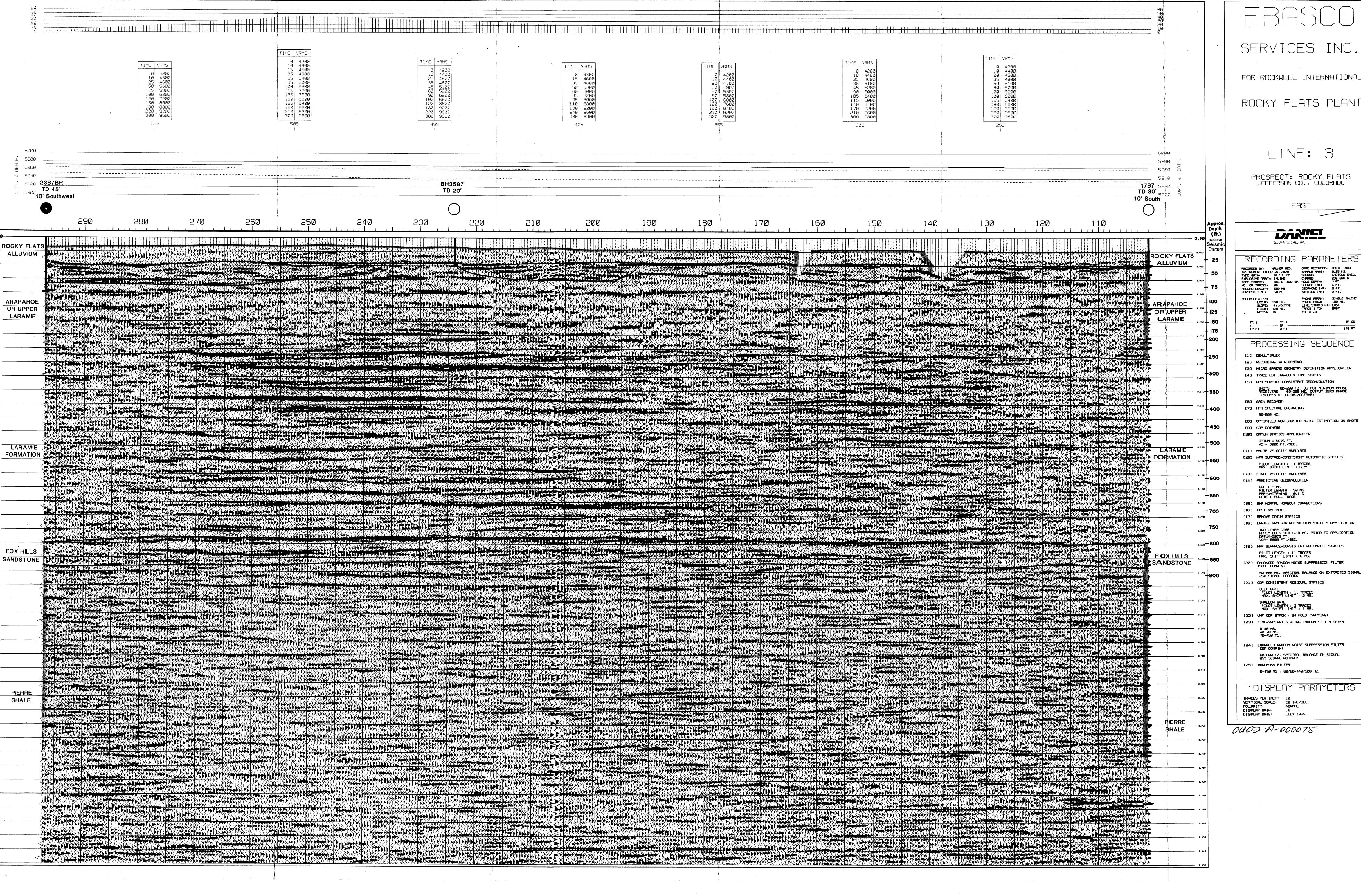
PROCESSING SEQUENCE

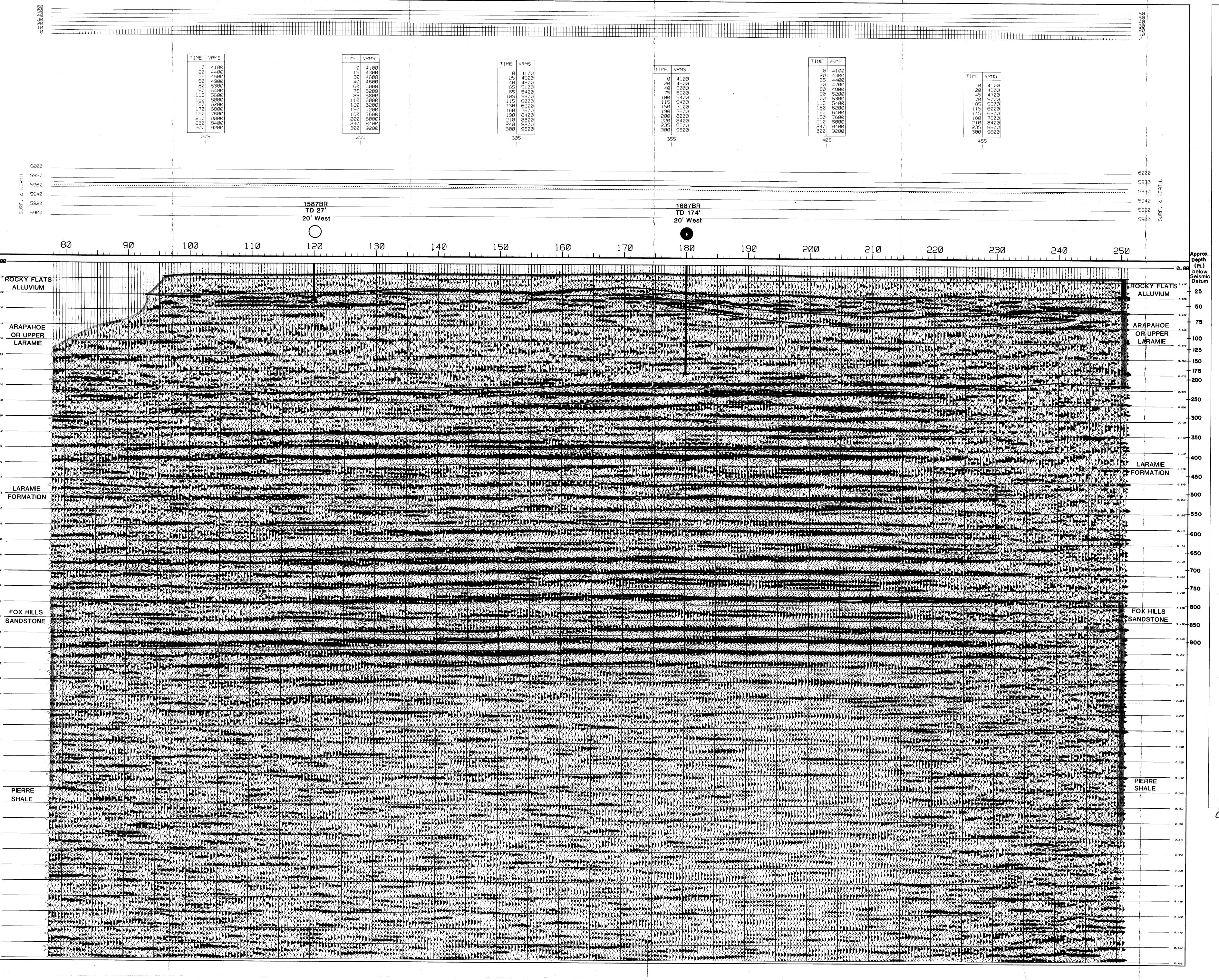
0-450 MS : 60/60-440/500 HZ.

DISPLAY PARAMETERS TRACES PER INCH: 10
VERTICAL SCALE: 50 IN./SEC.

POLARITY: NORMAL
DISPLAY GAIN: ,8
DISPLAY DATE: JULY 1989

DUOZ-A-000018





SERVICES INC.

FOR ROCKWELL INTERNATIONAL

ROCKY FLATS PLANT

LINE: 2

PROSPECT: ROCKY FLATS
JEFFERSON CO., COLORADO

DANIEL

LOCUT: 158 HZ.
SLOPE: 18 db/0CTAVE
HICUT: 729 HZ.
SLOPE: 52 db/0CTAVE

PROCESSING SEQUENCE

- [1] DEMULTIPLEX

[6] GAIN RECOVERY

- [10] DATUM STATICS APPLICATION

- [13] FINAL VELOCITY ANALYSES
- [14] PREDICTIVE DECONVOLUTION

- TWO LAYER CASE
 APPLY BULK SHIFT=18 MS. PRIOR TO APPLICATION
 DATUM=5975 FT.
 VCR= 5000 FT./SEC.

[19] HFR SURFACE-CONSISTENT AUTOMATIC STATICS

- [20] ENHANCED RANDOM NOISE SUPPRESSION FILTER
- DEEP GATE PILOT LENGTH : 11 TRACES MAX. SHIFT LIMIT : 2 MS.

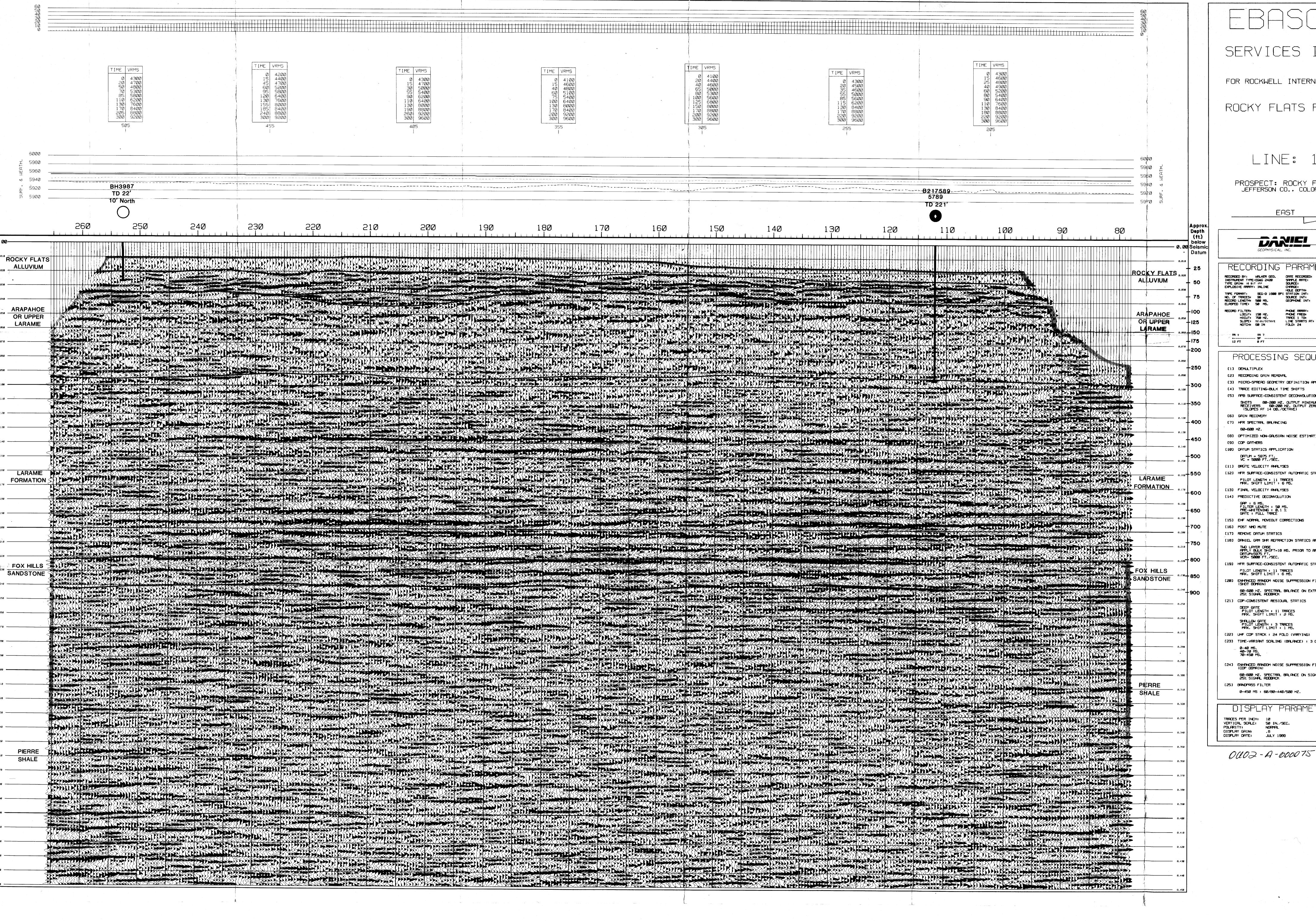
- [24] ENHANCED RANDOM NOISE SUPPRESSION FILTER (COP DOMAIN)
- 60-600 Hz. SPECTRAL BALANCE ON SIGNAL 25% SIGNAL ADDBACK

DISPLAY PARAMETERS TRACES PER INCH: 10
VERTICAL SCALE: 50 IN./SEC.

0402-A-000075

POLARITY:

DISPLAY GAIN: DISPLAY DATE:



SERVICES INC.

FOR ROCKWELL INTERNATIONAL

ROCKY FLATS PLANT

PROSPECT: ROCKY FLATS JEFFERSON CO., COLORADO

PROCESSING SEQUENCE

DISPLAY PARAMETERS

NOTICE

THIS FILE CONTAINS

DRAWINGS WHOSE

CONDITION AND / OR SIZE

PREVENTED THEM FROM

BEING SCANNED.